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IN THEIR WIDEST SENSE

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All naturalists who have anything interesting to say are invited to send in their contributions, but the editors will endeavor to select for publication only that which is of truly scientific value and at the same time written so as to be intelligible, instructive, and interesting to the general scientific reader.

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PLANTS USED BY THE INDIANS OF EASTERN NORTH AMERICA.

LUCIA SARAH CHAMBERLAIN.

THE following list of plants used by the North-American Indians inhabiting the country east of the Mississippi River was compiled during a course given to students of Radcliffe College in 1899–1900, at the Peabody Museum, by Dr. Frank Russell of the Department of American Archæology and Ethnology of Harvard University.

The linguistic groups of Indians included in this article are two: the Algonquian, the greatest family group and most prominent at the time of the settlement of the country by the whites; and the Iroquoian, who by their efficient organization became very powerful in the midst of the Algonquian country.

The arrangement of tribes under linguistic groups is that followed by the Report of the Bureau of Ethnology at Washington, D.C., for 1885–1886. The material was gleaned from the Harvard College Library, the Boston Public Library, the Boston Athenæum, the Cambridge Public Library, and the libraries of the Museum of Comparative Zoölogy and of the Peabody Museum.

ALGONQUIAN FAMILY.

Algonquin. — Derivation: contracted from *Algomequin*, an Algonquian word signifying "those on the other side of the river," *i.e.*, the St. Lawrence River.

TRIBES REPRESENTED.

Abnaki	Menomine	Pequot
Algonquin	Miami	Pottawotomi
Blackfeet	Micmac	Savannah
Delaware	Narragansett	Sax and Fox
Kickapoo	Ojibway	Shawnee

Abnaki.

Bayberry (**18**, p. 33)[1]: the wax obtained was used with tallow for candles. — **Bean** (**9**, p. 25): used as food. — **Birch bark** (**9**, p. 29): the Abnakis used it to write upon. — **Maize** (**9**, p. 25): used as food. — **Reeds** (**18**, p. 10): mats made of reeds served as chairs and beds. — **Squash** (**9**, p. 25): used as food.

Algonquin.

Birch (**17**, p. 310): bark used for sheathing the frame of canoes. — **Elm** (**17**, p. 310): bark used for sheathing the frame of canoes and the filaments of the bark used to sew the sheathing of canoes together. — **Fir** (**17**, p. 310): the gum used to cover seams of canoes. — **Flag** (**11**, p. 77): the leaves of sweet flag used to thatch huts. — **Maize** (**40**, p. 58): used as food and the leaves used to thatch huts. — **Pine** (**17**, p. 310): wood sometimes used in building frames of canoes. — **Rushes** (**11**, p. 77): used in making mats. — **Squash** (**11**, p. 77): used as food. — **Tamarack** (**17**, p. 310): roots used to sew the sheathing of canoes together. — **Tobacco** (**11**, p. 77): chewed by the Algonquins. — **Wild rice** (**26**, p. 205): used as food.

Blackfeet.

Berries (**17**, p. 278): esteemed a delicacy when boiled in buffalo blood. — **Bull berries**, *Shepherdia argentea* (**16**, p. 203): used as food. — **Camass root** (**4**, p. 534): roasted bulbs used as food. — **Chokecherries** (**16**, p. 203): pounded up before eating. — **Maize**, *Psoralea esculenta* (**5**, p. 205): used as food. — **Red willow** (**4**, p. 534): berries

[1] The figures in bold type refer to the bibliography at the end of the article.

used as food. — **Sarvis berries**, *Amelanchier alnifolia* (**16**, p. 203): dried and stored for food. — **Stork's bill**, *Erodium cicutarium* (**17**, p. 422).

Delaware.

Dogekumak (**7**, p. 96): smoked with tobacco. — **Maize** (**40**, p. 58): used as food; leaves used to thatch huts. — **Rushes** (**11**, p. 77): used for mats. — **Squash** (**11**, p. 77): used as food. — **Sweet flag** (**11**, p. 77): leaves used to thatch huts. — **Sumac** (**4**, p. 534): leaves smoked with tobacco. — **Tobacco** (**11**, p. 77): smoked. — **Willow** (**7**, p. 96): the bark of the red willow is mixed with tobacco.

Kickapoo.

Acorns (**21**, p. 265): used as food. — **Beans** (**21**, p. 265): used as food. — **Birch** (**21**, p. 301): bark used for canoes. — **Blackberries** (**21**, p. 265): used as food. — **Corn** (**21**, p. 265): used as food. — **Cottonwood** (**21**, p. 301): used for canoes. — **Crab apple** (**21**, p. 265): used as food. — **Dewberries** (**21**, p. 265): used as food. — **Gooseberries** (**21**, p. 265): used as food. — **Gourds** (**21**, p. 265): used as food. — **Grapes** (**21**, p. 265): many varieties used. — **Groundnuts** (**21**, p. 265): used as food. — **Hazelnut** (**21**, p. 265): used as food. — **May apple** (**21**, p. 265): used as food. — **Melons** (**21**, p. 265): used as food. — **Osage oranges** (**21**, p. 265): used as food. — **Peas** (**21**, p. 265): used as food. — **Pecans** (**21**, p. 265): used as food. — **Plums** (**21**, p. 265): used as food. — **Potatoes** (**21**, p. 265): used as food. — **Pumpkins** (**21**, p. 265): used as food. — **Strawberries** (**21**, p. 265): used as food. — **Sweet myrrh** or *anise root* (**21**, p. 265). — **Tobacco** (**21**, p. 265): smoked. — **Walnuts** (**21**, p. 265): used as food. — **Whortleberries** (**21**, p. 265): used as food. — **Wild licorice** (**21**, p. 265): used as food.

Menomine.

Ash (**32**, p. 274): used in making bows. — **Basswood** (**32**, p. 258): fibre used in making mats; the inner bark is used in making string and ropes; wood (**32**, p. 254) used in building houses. — **Birch** (**32**, p. 254): bark used to cover the top and side of houses; also for canoes. — **Blueberries** (**32**, p. 291): used as food. — **Cat-tail flags** (**32**, p. 258): used in making mats. — **Cedar** (**32**, p. 258): bark used in making mats; white cedar (**32**, p. 293) used in building canoes. — **Cherry** (**29**, p. 52): wild cherry used as food. — **Corn** (**29**, p. 48): used as food. — **Crab apple** (**29**, p. 52): used as food. — **Currants** (**29**, p. 52): used as food. — **Gooseberries** (**29**, p. 52): used as food. —

Grapes (**29**, p. 52): used as food. — **Hazelnut** (**29**, p. 52): used as food. — **Hickory** (**32**, p. 274): used in making bows. — **Hops** (**29**, p. 52): wild hops used as food. — **Maple**, *Acer saccharinum* (**32**, p. 237): maple sugar made from. — **Oak** (**32**, p. 253): used in building houses. — **Pine** (**32**, p. 254): bark used in building houses. — **Plums** (**29**, p. 52): used as food. — **Pumpkins** (**29**, p. 48): used as food. — **Raspberries** (**32**, p. 291): used as food. — **Rushes** (**32**, p. 258): used in making mats. — **Snakeroot**, *Polygala senega* (**32**, p. 292). — **Strawberries** (**29**, p. 52): used as food. — **Tobacco** (**32**, p. 253): used as food. — **Whortleberries** (**29**, p. 52): used as food. — **Wild rice** (**29**, p. 47): used as food.

Miamoi.

Yellow lily, *Lilium canadense* (**3**, p. 312): roots used.

Micmac.

Apios tuberosa, *Saa-ga-ban* (**4**, p. 534): pear-shaped roots used as food.

Narragansett.

Chestnut (**6**, p. 46): used for canoes. — **Pine** (**6**, p. 46): used for canoes. — **Whitewood** (**6**, p. 46): used for canoes.

Ojibway.

Basswood (**35**, p. 236): used in making nets. — **Birch** (**1**, p. 9): bark used for the exterior of canoes; characters traced upon the inner surface of bark; these characters usually pertain to personal exploits (**27**, p. 59). — **Cedar** (**9**, p. 116): bark used in making rope or twine; used in making nets (**35**, p. 236). White cedar used to make the hoops for canoes; the roots used in sewing canoes (**1**, p. 9). — **Cherry** (**1**, p. 9): gum used in putting canoes together. — **Corn** (**35**, p. 236): used as food. — **Groundnut** (**24**, p. 55): used as food. — **Pine** (**24**, p. 73): wood used in making fire by friction. — **Potatoes** (**35**, p. 236): used as food. — **Red willow** (**24**, p. 135): bark smoked. — **Root**, *Oduhpin* (**24**, p. 55): used as food sometimes. — **Spunk** (**24**, p. 73): wood used in making fire by friction. — **Sumac** (**24**, p. 135): leaves smoked. — **Swan potato**, *Wahbeziepin* (**24**, p. 55): boiled and eaten. — **Tobacco** (**24**, p. 56): leaves smoked. — **Wild rice** (**3**, p. 120): used for food.

Pequot.

Corn (**39**, p. 4): used as food. — **Indian hemp** (**39**, p. 2): used to make twine.

Pottawotomi.

Beans (**17**, p. 82): used as food. — **Maize** (**17**, p. 82): used as food. — **Melons** (**17**, p. 82): used as food. — **Tobacco** (**17**, p. 82): leaves smoked.

Savannah.

Chinkapin nuts (**25**, p. 53): used as food. — **Hickory nuts** (**25**, p. 53): used as food.

Sax and Fox.

Basswood bark (**29**, p. 126): twine obtained from it to bind rushes. — **Beans** (**29**, p. 126): used as food. — **Cane** (**14**, p. 43): flageolet made from it or of two pieces of soft wood hollowed out and fastened together by strips of leather. — **Corn** (**29**, p. 126): used as food. — **Gooseberries** (**14**, p. 29): used as food. — **Grapes** (**14**, p. 29): used as food. — **Melons** (**14**, p. 44): used as food. — **Nettle** (**29**, p. 126): twine obtained from the bark. — **Onions** (**4**, p. 534): used as food. — **Pecans** (**15**, p. 20): used as food. — **Plums** (**14**, p. 29): used as food. — **Potatoes** (**4**, p. 534): sweet and white potatoes used as food. — **Pumpkins** (**14**, p. 41): used as food. — **Rushes** (**29**, p. 126): mats made from. — **Sap pine**, *Kee-chi-he-ja-ka* (**22**, p. 419): a healing gum which the Sax and Fox always take with them when they travel.

Shawnee.

Apple, *meshemenake* (**2**, p. 291): used as food. — **Beans**, *misoochethake* (**2**, p. 291): used as food. — **Indian turnip**, *e-hawe-sho-ga* (**22**, p. 413): used with spikenard and wild licorice. — **Maize** (**19**, p. 14): used as food. — **Melons**, *usketomake* (**2**, p. 291): used as food. — **Nuts**, *pacami* (**2**, p. 291): used as food. — **Onions**, *shekagosheke* (**2**, p. 291): used as food. — **Peaches** (**40**, p. 17): used as food. — **Peas** (**19**, p. 14): several kinds used as food. — **Potatoes**, *meashethake* (**2**, p. 291): used as food. — **Pumpkins**, *wabego* (**2**, p. 291): used as food. — **Squashes** (**40**, p. 17): used as food. — **Tobacco** (**40**, p. 57): leaves smoked. — **Wheat**, *cawasque* (**2**, p. 291): used as food.

IROQUOIAN FAMILY.

Iroquois. — Derivation: the adaptation of the Iroquois word *hiro*, used to conclude a speech, and *koué*, an exclamation. (**Charlevoix.**)

TRIBES REPRESENTED.

Cayuga	Mohawk	Seneca
Cherokee	Oneida	Tuscarora
Huron	Onondaga	Wyandot

Cayuga.

Buckwheat (**36**, p. 58): used as food. — **Corn** (**36**, p. 57): used as food. — **Oats** (**36**, p. 58): used as food. — **Potatoes** (**36**, p. 58): used as food. — **Wheat** (**36**, p. 58): used as food.

Cherokee.

Apples (**12**, p. 11): used as food. — **Beans** (**28**, p. 69): used as food. — **Beggar's lice** (**12**, p. 11): tea made of it to assist the memory "since it clings so well." — **Blackberries** (**12**, p. 11): used as food. — **Chestnut** (**28**, p. 69): a tuberous root used as food. — **China brier** (**23**, p. 34): roots used as a blood purifier. — **Cone flower** (**20**, p. 197): used as a wash for sore eyes. — **Grapes** (**5**, pp. 228–29): used as food. — **Hemp** (**5**, pp. 228–29): used for cords. — **Hoary pea**, *Tephrosia virginiana* (**12**, p. 11): an infusion of it used as a wash to strengthen the body. — **Hops** (**5**, pp. 228–29): used as food. — **Horehound** (**5**, p. 235): wild horehound used for snake bite. — **Lobelia**, *Lobelia cardinalis*, cardinal flower (**8**, p. 41): a decoction of the root used. *Lobelia syphilitica*, great lobelia (**23**, p. 34): a blood purifier. — **May apple**, *Podophyllum peltatum* (**23**, p. 34): used as medicine. — **Nettle**, *Jatropha ureus*, white nettle (**23**, p. 34): roots used as medicine. — **Nordica** (**23**, p. 34): the juice of its white root used as medicine, and its roots smoked. — **Oats** (**12**, p. 11): cultivated as food. — **Peaches** (**12**, p. 11): used as food. — **Plantain** (**5**, p. 235): wild plantain used for snake bite. — **Potatoes** (**12**, p. 11): used as food. — **Pumpkins** (**28**, p. 69): used as food. — **Purslane**, *Portulaca oleracea* (**20**, p. 197): used as medicine. — **Rye** (**12**, p. 11): cultivated as food. — **Sarsaparilla**, *Panax ginseng* (**23**, p. 34): used as medicine. **Sassafras** (**23**, p. 34): roots used as a blood purifier. — **Snakeroot** (**5**, p. 235): fern snakeroot carried in the shot pouch as a remedy for snake bite. — **Squashes** (**28**, p. 69): used as food. — **St. Andrew's cross** (**5**, p. 235): used for snake bite. — **Strawberries** (**12**, p. 11): used as food.

Huron.

Beans (**38**, p. 13): cultivated as food. — **Birch** (**13**, p. 73): white birch bark used to cover lodges. — **Blackberries** (**33**, p. 143): used as

food. — **Corn** (**33**, p. 168): used as food. — **Gooseberries** (**33**, p. 143): used as food. — **Grape** (**33**, p. 153): used as food. — **Hemp** (**38**, p. 13): fibre used for twine and cordage. — **Lichen** (**33**, p. 142): *tripe de roche*, boiled and used as food. — **Pumpkins**, or *citrulles* (**33**, p. 163): used as food. — **Squashes** (**38**, p. 13): cultivated as food. — **Tobacco** (**38**, p. 13): cultivated, leaves smoked. — **Wild rice** (**13**, p. 73): "the stalk is woven into mats for the walls of the lodges"; fruit used as food.

Mohawk.

Corn (**36**, p. 52): cultivated as food.

Oneida.

Corn (**36**, p. 43): cultivated as food.

Onondaga.

Apple, *swa-hu-na* (**10**, p. 115). — **Basswood**, *ho-ho-so* (**10**, p. 116): used to make fine strings and mats. — **Beans**, *oo-sah-ha-tah* (**10**, p. 119): used as food. — **Birch**, *ga-nah-jeh-kwa* (**10**, p. 116): used for canoes. — **Blackberry**, *sa-he-is* (**10**, p. 116): used as food. — **Butternut**, *ooo-ha-wat-tah* (**10**, p. 119): used as food. — **Cat-tail flag**, *oo-na-too-kwa* (**10**, p. 118): used for mats. — **Cherry**, *ja-e-goo-nah* (**10**, p. 114): wood used. — **Chestnuts**, *oheh-yah-tah* (**10**, p. 116): used as food. — **Chokecherry**, *ne-a-tah-tah-ne* (**10**, p. 114): used as food. — **Currant**, *ska-heus-skah-he* (**10**, p. 119): used as food. — **Flax**, *ooo-skah* (thread-like) (**10**, p. 117): used to make thread. — **Ginseng**, *da-kien-too-keh* (**10**, p. 115). — **Gooseberry**, *ska-heus-skah-he-goo-na* (**10**, p. 114): used as food. — **Grape**, *oh-heun-kwe-sa* (**10**, p. 114): wild grape, used as food; *oh-heun-kwe-so-goo-no*, cultivated grape, used as food. — **Hickory**, *a-nek*, a bitter nut. *us-teek* (**10**, p. 120). *Oo-sook-wah*, common variety of hickory. — **Huckleberry**, *o-heah-che* (**10**, p. 116): used as food. — **Lettuce**, *oo-na-tah-kah-te* (**10**, p. 115): eaten raw. — **Maize**, *oo-ne-hah* (**10**, p. 119): used as food. — **May apple**, *o-na-when-stah* (**10**, p. 115): used as food. — **Melon.** *wah-he-yah-yees* (**10**, p. 114): muskmelon, used as food. *Oo-neah-su-kah-te* (**10**, p. 114): watermelon, used as food. — **Peaches**, *oo-goon-why-e* (**10**, p. 114): used as food. — **Pear**, *koon-de-soo-kwis* (**10**, p. 114): used as food. — **Peas**, *o-na-kwa* (**10**, p. 119): used as food. — **Peppermint**, *kah-nah-noos-tah* (**10**, p. 116). — **Plum**, *ka-ka-tak-ne* (**10**, p. 118): wild plum, used for food. — **Potato**, *oo-neh-noo-kwa* (**10**, p. 119): used as food. — **Raspberry**, *o-nah-joo-kwa* (**10**, p. 116): used as food. *Tew-tone hok-toon* (**10**, p. 116): black

raspberry, used as food. — **Rose**, *ah-weh-ha-tah-ke* (**10**, p. 118): wild rose, used as medicine. — **Sarsaparilla**, *ju-ke-ta-his* (**10**, p. 116). — **Snakeroot**, *o-skwen-e-tah* (**10**, p. 120). — **Squash**, *oo-neah-sah-oon-we* (**10**, p. 114): used as food. — **Strawberry**, *noon-tak-tek-hah-kwa* (**10**, p. 114): used as food. — **Sumac**, *oot-koo-tah* (**10**, p. 119): leaves smoked. — **Thimbleberry**, *o-nah-joo-kwa-goo-na* (**10**, p. 116): used as food. — **Tobacco**, *o-yen-kwa-hon-we*, *Nicotiana rustica* (**10**, p. 118): leaves smoked. — **Turnip**, *o-je-kwa* (**10**, p. 115): used as food. — **Wake-robin**, *o-je-gen-stah* (**10**, p. 117); white wake-robin; medicinal use not known to the Onondagas.

Seneca.

Apples (**37**, p. 18): used as food. — **Ash** (**34**, p. 49): used to make baskets. — **Basswood** (**37**, p. 20): leaves used. — **Beach plums** (**37**, p. 18): used as food. — **Beans** (**37**, p. 18): used as food. — **Black walnuts** (**37**, p. 18): used as food. — **Corn** (**37**, p. 18): used as food; husks used to make baskets (**34**, p. 49). — **Groundnuts** (**37**, p. 18): used as food. — **Hazelnuts** (**37**, p. 18): used as food. — **Hickory** (**34**, p. 49): snowshoes made from the wood. — **High-betony** (head-betony) (**37**, p. 20). — **Mandrakes** (**37**, p. 18): used as food. — **Maple** (**34**, p. 48): sugar made from the sap. — **Mulberries** (**37**, p. 18): used as food. — **Ookithaw** (**37**, p. 18): a root used to make bread. — **Peaches** (**37**, p. 18): used as food. — **Potatoes** (**37**, p. 18): used as food. — **Rushes** (**34**, p. 49): used to make baskets. — **Squashes** (**37**, p. 18): used as food. — **Sumac** (**34**, p. 49): leaves mixed with tobacco. — **Tobacco** (**34**, p. 49): leaves smoked.

Tuscarora.

Beans (**36**, p. 69): used as food. — **Buckwheat** (**36**, p. 69): used as food. — **Corn** (**36**, p. 69): used as food. — **Oats** (**36**, p. 69): used as food. — **Peas** (**36**, p. 69): used as food. — **Potatoes** (**36**, p. 69): used as food. — **Turnips** (**36**, p. 69): used as food. — **Wheat** (**36**, p. 69): used as food.

Wyandot.

Beans, *yah-re-sah* (**2**, p. 294). — **Corn**, *nay-hah* (**2**, p. 294). — **Grass**, *e-ru-ta* (**2**, p. 294). — **Melons**, *o-nugh-sa* (**2**, p. 294). — **Potatoes**, *da-ween-dah* (**2**, p. 294). — **Pumpkins**, *o-nugh-sa* (**2**, p. 294). — **Weeds**, *ha-en-tan* (**2**, p. 294).

CAMBRIDGE, MASS., August 31, 1900.

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ON THE SYSTEMATIC POSITION OF THE SAND GROUSE (PTEROCLES; SYRRHAPTES).

R. W. SHUFELDT.

THERE has been no question for many years past, in the minds of avian taxonomers, as to the general affinities of these birds. This opinion may be briefly stated by saying that the sand grouse constitute a small assemblage of forms, related on the one hand to the gallinaceous birds, and on the other to the pigeons.

Some authors have relegated them to a distinct group, placing it in their schemes of classification between the fowls and the Columbæ. Huxley created the Pteroclomorphæ for them, and Sclater, regarding them as a family, Pteroclidæ, placed them in the order Pterocletes, standing between the Columbæ and the Gallinæ, and in this he has been followed by Stejneger and others. Garrod, Fürbringer, and other authorities, again, have arrayed them with the pigeons. Numerous papers have been devoted to their osteology, but the best of these is doubtless the one given us years ago by William Kitchen Parker, in the *Transactions of the Zoölogical Society of London* (V, 149), where they are treated in his memoir entitled "On the Osteology of the Gallinaceous Birds and Tinamous." The plates to his memoir illustrate the skeleton of *Syrrhaptes paradoxus*, while in the text we have a more or less extensive comparison of the osseous system of this species with that of *Pterocles arenarius*. Parker's figures are very helpful, and in addition to them I have examined some bones of Syrrhaptes loaned me by Professor Alfred Newton, F.R.S., and there are also at hand the mounted skeleton (see plate) and disarticulated one of *Pterocles arenarius*, belonging to the collections of the United States National Museum, and other material.

One has but to glance at the skull of Pterocles to be satisfied that the bird is not a pigeon, while, on the other hand, it

brings to mind the skulls of some of the smaller grouse or ptarmigans. The cervico-dorsal region of the skeleton also is by no means truly columbine, though without difficulty we can

Skeleton of Sand Grouse (*Pterocles arenarius* Pallas). No. 18,849, Coll. U. S. Nat. Museum.
Reduced about one-third.

see the pigeon in the pectoral limb, the sternum, the pelvis, the ribs perhaps; but to a less extent in the shoulder girdle and the bones of the pelvic extremities.

The form of the premaxillary is gallinaceous, the sutural traces of its proximal frontal process being distinct throughout life over the facial frontal region in the middle line, as we see it in many fowls. The large narial openings are elliptical in outline, and made even more so by a curled osseous extension upon either side of the inner nares, that is, above and in front of the very large pars plana, below and in front of the frontal, touching the nasal externally and the premaxillary internally, while its upper part, with its free anterior edge, is in full view upon superior aspect of the skull. A few small, irregular vacuities may occur in the interorbital septum, but the good-sized orbit has upon all sides well-defined bony walls, the frontal roof overhead being well produced, the pars plana large and concaved upon its posterior aspect, the anterior part of the brain-case complete; while quadrate, pterygoid, and palatine afford a fairly good osseous floor.

The postfrontal processes are more or less aborted, and the squamosal ones are thin and lamelliform, as in the chickens, — the two apophyses not coming in contact distally.

At the base of the skull the palatines are of extremely slender construction, and widely separated from each other in the middle line. They do not even come in contact across the sphenoidal rostrum, which latter is much thickened and rounded, being pointed anteriorly, where it is carried beyond the pars plana.

Either maxillo-palatine is a mere rudimentary spine, so small that the thread-like anterior rod of the corresponding palatine almost conceals it from view, when the skull is looked at from this side. A pterygoid is also very slender, and presents a somewhat flattened sigmoid curve at its middle part. These bones articulate with pteryapophysial processes at the cranium's base. No vomer seems to be present, and the nasal septum is but very imperfectly performed in bone.

The zygomatic arches are slender and straight, while the quadrates are well developed and present no very unusual characters.

The mandible, of a V-pattern, resembles to no small extent that bone in some of the smaller ptarmigans (Lagopus). A

good-sized ramal vacuity is present in either ramus, and the straight and blunt angular processes are considerably produced.

Kitchen Parker has said the "differences between the skull of *Pterocles arenarius* and *Syrrhaptes paradoxus* are not great, but are important. The head and face of the former are altogether stronger, more gallinaceous and less pigeon-like, than in the latter. The skull base has, in the Pterocles, that peculiar breadth which arises from the struthiousness of its structure. The upper frontal region is broader between the eyes, and the alæ of the ethmoid swell up to a greater extent between the crura of the nasal. The postorbital and squamosal processes are much stronger, and make a thicker bridge over the temporal fossa. The crossing of the posterior and horizontal semicircular canals project in the same hemispherical manner as in Syrrhaptes, and the tympanic ala of the lateral occipital is equally arrested."

"The molar arch is stronger, and the central interorbital space is filled up;[1] so also are the orbito-frontal fontanelles; the common optic foramen is more closely and neatly circumscribed. There is still an oval slit, opening into both orbits, between the ethmoid bar and the lower edge of the frontals at their coalescence. The antorbital lachrymal mass is equally large, and the septum nasi as well developed and as completely ossified.[2]

"The bones of the face generally are quite as strong as in ordinary pigeons, and therefore a degree beyond what is seen in Syrrhaptes. The double head of the os quadratum agrees with the same structure in Syrrhaptes, and there is nothing special to remark upon in the bones of the palatine region. The lower jaw is altogether stronger and deeper, its bend is more marked and further back, than in that of Syrrhaptes; the membranous space is of about the same size, as are also the angular processes."[3] There is an excellent account of the skull of Syrrhaptes, including the bones of the tongue, etc., in the work of Professor Parker just quoted. It is interesting to

[1] Not so in all specimens. — R. W. S.

[2] The septum narium does not always completely ossify in all individuals of this group; it may, however, do so in the skulls of very old specimens. — R. W. S.

[3] On the Osteology of Gallinaceous Birds and Tinamous (p. 204).

note that in Syrrhaptes there are sixteen cervical vertebræ; fifteen in *Pterocles arenaria;* and but fourteen in *Ectopistes migratorius*. Again, in Syrrhaptes, *three* of the dorsal vertebræ coössify into one piece, the fourth dorsal remaining free. This agrees with Ectopistes; while in *Pterocles arenarius*, *four* dorsals coössify to form a single piece, and posterior to this another free dorsal vertebra is found, making five. This, with many similar points in its skeleton, goes to show that Syrrhaptes is nearer the pigeons than is Pterocles; yet neither of these forms are truly columbaceous.

In the pelvis of either genus we find just such a bone as we should expect to find in birds that are doubtless typical intermediates, standing directly in their organization between two well-circumscribed groups. In the sand grouse, however, the lateral portions of the pelvic sacrum, at its widest part, fail to ossify, and thus, in the dried skeleton, leave large vacuities in that region not seen in tetraonine nor typical columbine birds.

There is usually one less *sacral* vertebra in pigeons than there is in the sand grouse, the former having fourteen, while Syrrhaptes and Pterocles have fifteen; and Parker claims that the last has but six vertebræ in its tail, and this is all I find in Ectopistes, while *Columba livia* and *Pterocles arenarius* each possess seven.

Professor Parker is correct when he says, "I do not set much value on the number of caudal vertebræ, as the last is a series, and the tail is very apt to vary in the number of those which shall be swallowed up in this terminal piece."

The epipleural processes on the ribs are much broader and deeper in *Pterocles arenarius* than they are in Ectopistes and other pigeons.[1]

In Pterocles the scapulæ are long, narrow, and tapering, reaching, in fact to some extent overreaching, the ilia of the pelvis posteriorly. In Ectopistes these bones are cimeter-

[1] In the autumn of 1899 Professor C. O. Whitman requested me to write out for him a complete account of all the species of the North American pigeons, in so far as their osteology was concerned, as a contribution to the *Journal of Morphology*. This I did, illustrating the memoir with several figures of the bones of the birds of that group, and a number of the points referred to in the present paper will therein be illustrated. It was accepted for publication and will in due course appear in the aforesaid journal, probably some time in 1901. — R. W. S.

shaped, and both dilated as well as truncated behind, where they do not reach the ilia by any means. Pterocles has a very insignificant fourchette in its shoulder girdle, slender and of a U-pattern. Its clavicular ends articulate with the scapulæ. This they fail to do in all the pigeons I have examined, where the bone has much the same form and slenderness, but reaches a great deal farther down towards the carinal angle of the sternum. As already stated above, both the sternum and the upper extremity of Pterocles are quite columbine in character, especially the former. Its sternum has considerably more pigeon than it has grouse in it, and as this bone is often seized upon by some avian classifiers as *the* index of a bird's systematic position and its affinities, it may account for the sand grouse having been placed upon the columbine side of the line in certain schemes of classification.

With a strong columbo-tetraonine tincture in it, the pelvic limb of *Pterocles arenarius* has characters in it not commonly, if ever, found in those allied groups. In *P. arenarius* (No. 18,849, Coll. U. S. Nat. Mus.) the first metatarsal coössifies with the tarso-metatarsus; is high up on the shaft; and the basal hallucial joint, with its unequal phalanx, is very rudimentary. There are but three joints and a claw in either outer podal digit; while the limb below the knee (there being no patella) is well supplied with sesamoids. One great grooved one is found back of the tibio-tarsal condyles, and two or three small ones in the sole of the curious foot of this bird. Air does not gain access into the shafts of the long bones of the pelvic limb of Pterocles; and this also holds true for Syrrhaptes (Parker).

As to the systematic position of the sand grouse, it may be briefly said that there is altogether too much grouse in the skull of Pterocles to admit of its being arrayed with the Columbæ; while, on the other hand, there is too much pigeon in both Pterocles and Syrrhaptes to admit of placing either of these genera in the tetraonine assemblage. The place they really hold is an intermediate one, and this is best shown, I think, and the ends of classification best served, by arraying them in a separate group, — the suborder Pterocles, standing between the Galli and the Columbæ.

CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE. E. L. MARK, DIRECTOR. No. 118.

CORRELATED ABNORMALITIES IN THE SCUTES AND BONY PLATES OF THE CARAPACE OF THE SCULPTURED TORTOISE.

G. H. PARKER.

A TYPICAL carapace of the sculptured tortoise (*Chelopus insculptus* LeC.) is composed of fifty bony plates, so united as to form a strong dorsal shield, and of thirty-eight horny scutes covering this shield externally. These elements are arranged as shown in Fig. 1, in which the black lines represent the limits of the bony plates, and the lighter ones those of the scutes. The scutes form three series: first, a median set, which, beginning at the anterior end and proceeding posteriorly, consists of a narrow nuchal scute, five large central scutes, and a pair of pygal scutes, one right and the other left; secondly, four pairs of large **centro-lateral scutes,** which flank the median series, except at the anterior and the posterior ends; and, thirdly, eleven pairs of marginal scutes,

FIG. 1. — Dorsal view of a normal carapace of a male sculptured tortoise. The faint whitish lines represent the edges of the scutes, which were removed in making the preparation: the black lines mark the margins of the bony plates. × ⅔

which bound the periphery of the carapace, except where the nuchal and the pair of pygal scutes reach the edge. The bony plates (Fig. 1, black outlines) are also arranged in three series. The median one is composed of twelve plates, which, beginning at the anterior end, are, first, a large nuchal plate; next, eight neural plates; and, finally, three pygal plates, one behind the other. Eight pairs of costal plates abut with their central ends on the median series, and extend laterally well towards the edge of the carapace. Excepting where the nuchal plate and last pygal plate reach the edge, the carapace is bounded by eleven pairs of marginal plates. Although the scutes and bony plates are arranged upon similar plans, the two sets of elements do not coincide either in numbers or in exact positions.

The first abnormal specimen to be described is one (Museum, No. 1829) from the extensive series by which this species is represented in the collections of the Museum of Comparative Zoölogy at Harvard College, Cambridge. It is a male and was collected at Lancaster, Mass. My thanks are due Mr. Samuel Garman for having called my attention to it, as well as the authorities of the museum for their liberality in allowing me to dissect such parts as were needed. The carapace, which was about 15 cm. long and 11.3 cm. broad, had suffered somewhat from marginal fractures, but in no instance had a whole scute or plate been lost through such injuries.

FIG. 2. — Dorsal view of abnormal carapace No. 1 (Mus. Comp. Zoöl., No. 1829). The black lines give the outlines of the scutes. × ½.

The arrangement of the scutes is given in Fig. 2, an examination of which shows that there are two abnormal regions:

first, the middle and posterior parts of the median series; and, secondly, the anterior parts of the marginal series.

In the median series the nuchal and first central scutes are essentially normal. The second central is irregular on its posterior margin; the third and fourth centrals are apparently each divided in two by nearly parallel oblique lines; and the fifth central is irregular anteriorly. The second, third, and fourth centro-laterals of the right side are also irregular in form. To the right of the fifth central is a small supernumerary scute, which may represent a part of any one of the surrounding elements except the marginals. These are apparently not involved in the irregularity, whose center obviously lies to the right of the median line in the region of the third and fourth centrals.

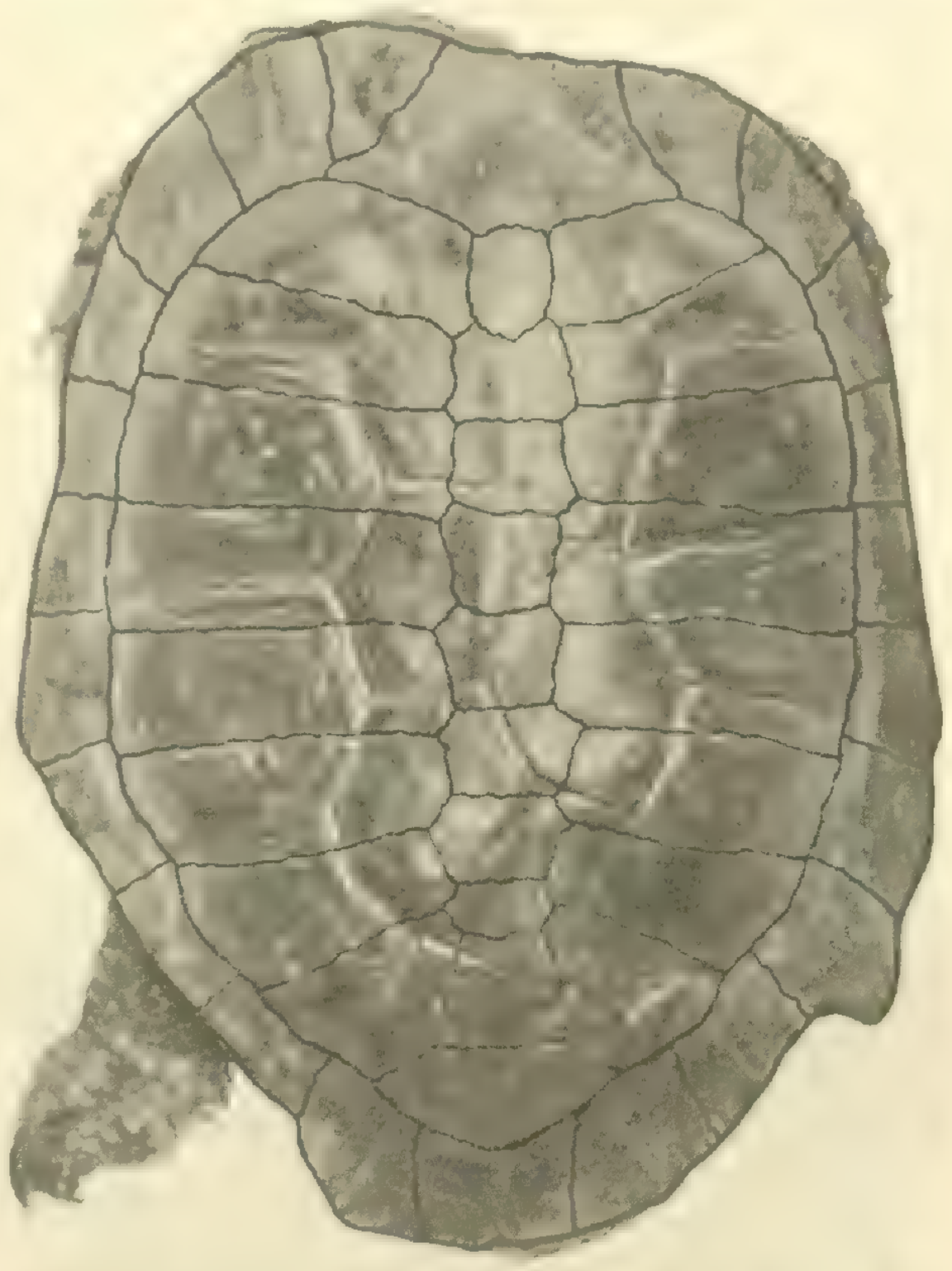

FIG. 3. — Dorsal view of abnormal carapace No. 1. The black lines give the outlines of the bony plates. × ½.

When the bony plates underlying the region of irregularity just described are inspected (Fig. 3) they are seen to present no features essentially different from the normal arrangement, and it is, therefore, clear that in this region the abnormalities are limited to the scutes and are not associated with any peculiarities of the underlying bony plates.

The second abnormal region in this carapace lies anteriorly and is easily recognized by peculiarities in the marginal scutes (Fig. 2). If the lines of separation between the first and second centro-lateral scutes of both sides are traced laterally, they will be found to be continuous with lines between marginal scutes. These intermarginal lines are undoubtedly a

natural pair, because posterior to each there are seven marginals and one pygal — a condition which is identical with that in the normal carapace (compare Fig. 1). Anterior to these lines, however, the right and left sides of the carapace are different; on the right side are three marginals, on the left four. As the left side has the normal number of marginal scutes, the abnormality may be described as a deficiency on the right side, an interpretation that is supported by the fact that the outline of this side recedes more than is usual in this species (compare Figs. 1 and 2). Since the right side is normal from the fourth intermarginal line posteriorly, the deficiency may with fairness be said to lie in the region covered in this specimen by the first three marginals.

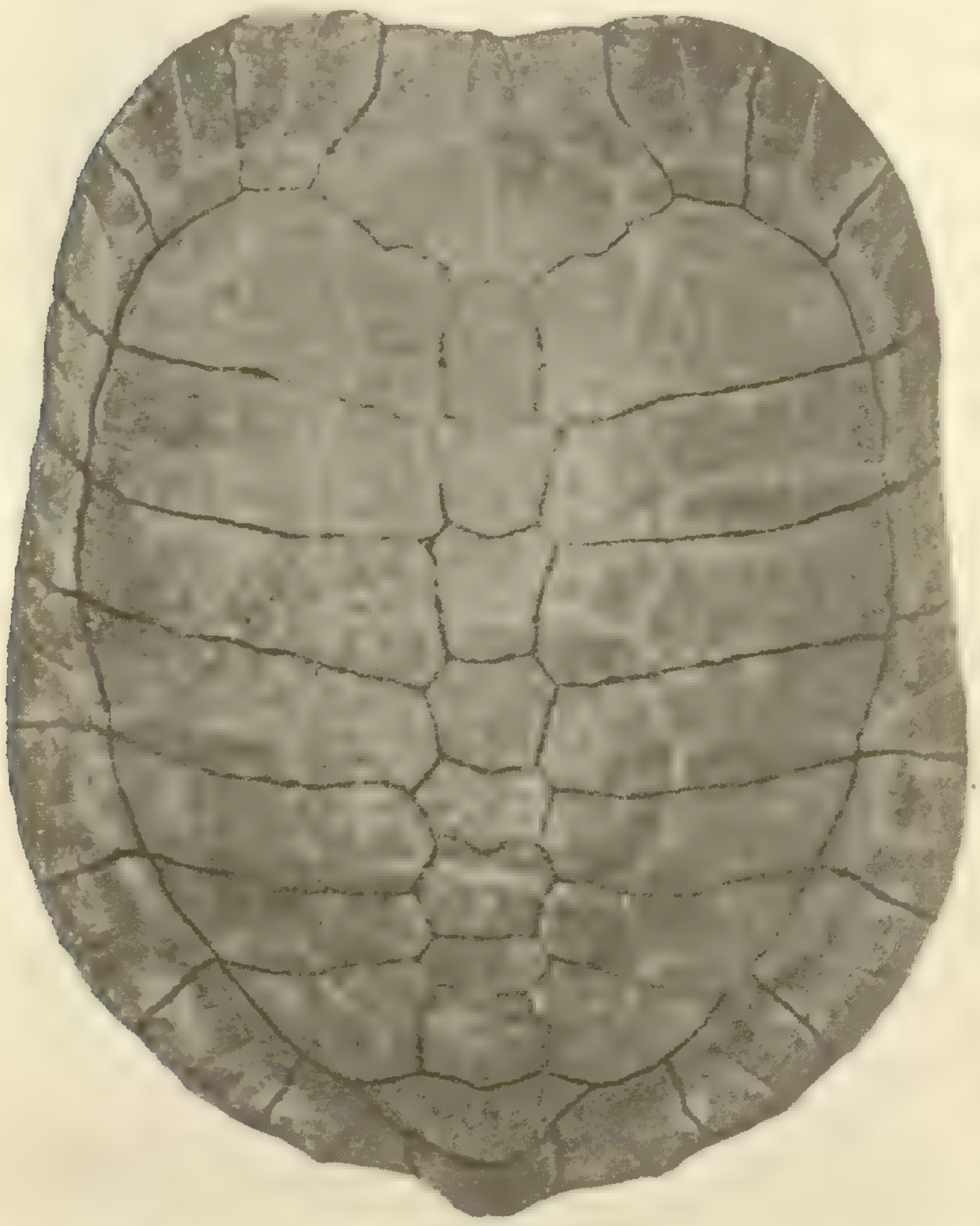

FIG. 4. — Dorsal view of abnormal carapace No. 2. The black lines are the outlines of the bony plates. × ½.

An examination of the bony plates in the marginal series of this carapace (Fig. 3) shows a condition substantially like that just described. The first four marginal plates of the left side occupy a region which corresponds to that covered by the first three marginals of the right. The total number of marginal plates on the left side is eleven, and this side may be described as essentially normal, notwithstanding the fact that the first marginal is triangular instead of quadrilateral. The total number of marginals on the right side is ten, and the deficiency, as can be seen by a comparison with a normal specimen (Fig. 1), lies in the region covered by the first three plates. As this is the region from which a scute is absent, the conclusion is warranted that, in this instance, the absence of a

bony plate is accompanied by the absence of an overlying scute. Thus the first specimen illustrates two conditions: scute abnormalities *unassociated* with bony abnormalities, as seen in the median and right centro-lateral parts; and scute abnormalities *correlated* with bony abnormalities, as seen in the anterior portion of the right marginal series.

The second abnormal carapace was brought to my attention by Mr. C. E. Preston, to whom the specimen had been assigned for study, and who kindly prepared it for me. The animal was a male and came in all probability from Maryland. Its carapace, when prepared, measured about 15.7 cm. in length and 12.1 cm. in breadth.

At first sight the carapace (Fig. 4) does not seem to be abnormal, but a closer inspection shows that there must be at least two abnormal regions, one in the scutes and the other in the bony plates; in both instances the abnormalities form symmetrical areas. The scute abnormalities occur in the posterior part of the marginal series. On both sides marginals 1 to 8 are entirely normal. In typical specimens (Fig. 5, *a*) marginal 8 is followed on either side by four scutes, — marginals 9, 10, 11, and the pygal scute. In the abnormal specimen (Fig. 5, *b*), in place of these four scutes, only three are present. As it is impossible to state which scute of the four is absent, the condition may be described as a bilateral deficiency of one scute posterior to marginal 8.

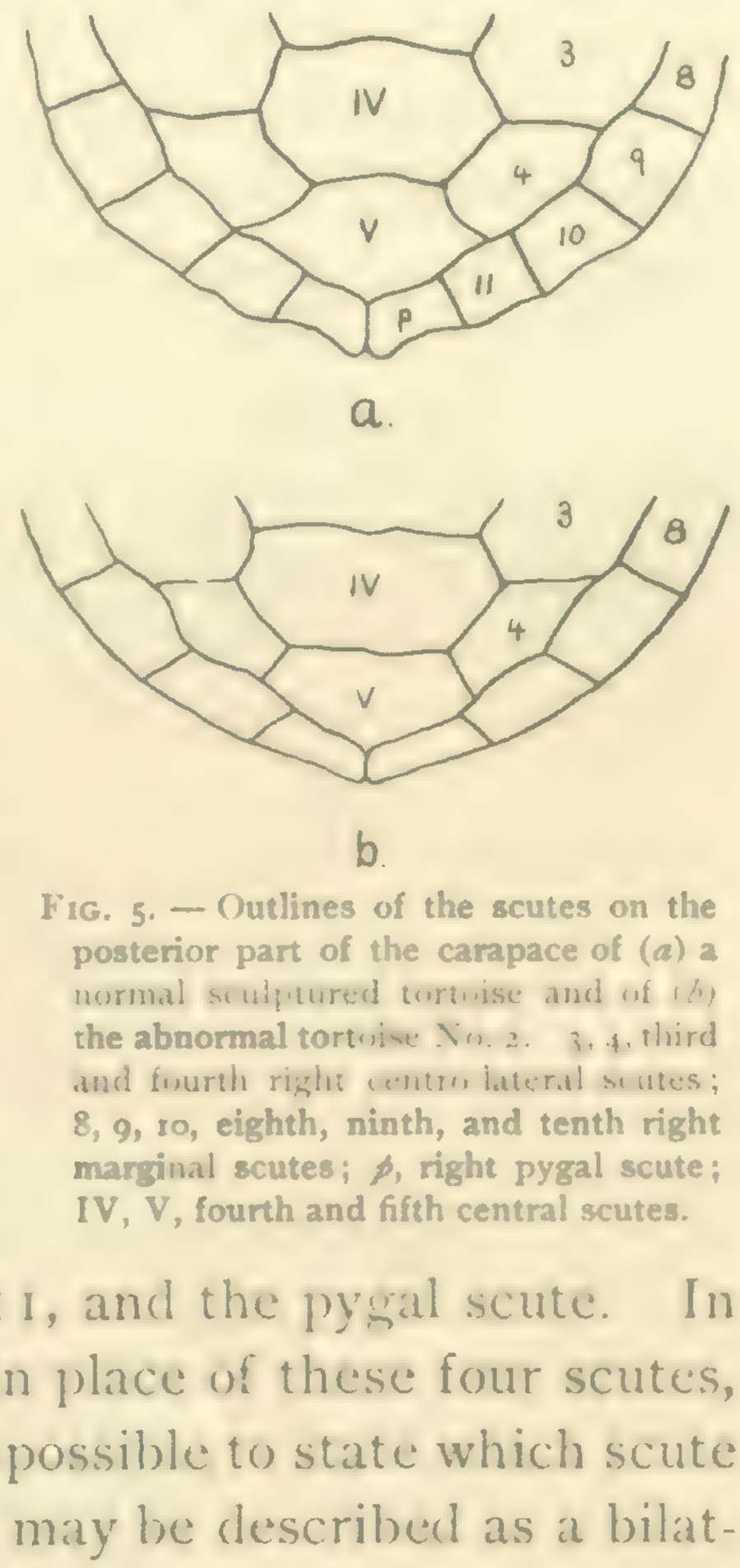

FIG. 5. — Outlines of the scutes on the posterior part of the carapace of (*a*) a normal sculptured tortoise and of (*b*) the abnormal tortoise No. 2. 3, 4, third and fourth right centro lateral scutes; 8, 9, 10, eighth, ninth, and tenth right marginal scutes; ♁, right pygal scute; IV, V, fourth and fifth central scutes.

The bony plates of this specimen in the regions where scute abnormalities occur are essentially normal (Fig. 4), and the same may be said of those at the anterior end of the carapace. In fact, judging from the number and shapes of the plates, normal conditions may be said to exist between the anterior edge of the carapace and the transverse line marked by the

posterior borders of the first costal plates, and between the posterior edge of the carapace and the transverse line marked by the anterior borders of the next to the last pair of costal plates. The rest of the carapace is made up of four bony segments instead of the five which are typical of normal individuals (Fig. 1). In this abnormal specimen, therefore, a whole bony segment (a neural plate, a pair of costals, and a pair of marginals) is absent, and the position of the deficiency is somewhere between the posterior edge of the first pair of costals and the anterior edge of the next to the last pair of costals, *i.e.*, in the body of the carapace.

Such a suppression might be expected to be accompanied by a shortening of the carapace, and, as a matter of fact, there is some evidence that this is so. The length of the carapace under consideration is 15.7 cm., its breadth 12.1 cm.; the length is, therefore, 1.298— times the breadth. In ten normal males taken at random the average length of their carapaces was 16.65 cm., and the average breadth 12.68 cm.; the average length was therefore 1.313 + times the average breadth. It thus appears that the abnormal specimen is somewhat shorter than the average normal specimen, both absolutely and relatively to its length, — a condition to be expected if the suppression of a segment is assumed.

Although the second specimen shows abnormal conditions in both scutes and bony plates, the fact that the two abnormal regions do not overlap even in part (for the most posterior position assignable to the bony-plate abnormality is still anterior to the most anterior position assumable for the scute abnormality) might well lead to the inference that these two irregularities were in no true sense correlated. Such a conclusion, however, is probably incorrect. The fact that neither of the two abnormalities interferes with bilateral symmetry at least suggests something more than an accidental relation, though it in no wise meets the objection that the abnormalities are not superimposed. This objection, however, is not as serious as at first sight it seems to be. Harrison ('98) some time ago showed by a series of ingenious experiments on young tadpoles that in the growth of the posterior parts of

their bodies the germ layers undergo a curious change in position. The tail of a developing tadpole is composed of an outer covering of ectoderm — which ultimately gives rise to the outer layers of the skin — and of a core of mesoderm. These two masses of tissue grow in very different ways, so that as the tail lengthens the ectodermic covering, which is most actively produced anteriorly, slips posteriorly over the underlying mesoderm, whose region of growth is chiefly at the posterior end. Although this posterior migration of the ectoderm has been actually demonstrated only in the tadpole, there is reason to believe that it occurs in other vertebrates. Admitting its existence in the turtle, it affords an easy means of explaining the conditions described. The scutes of turtles are derived from the ectoderm, the bony plates from the mesoderm. In the anterior part of the carapace these ectodermic and mesodermic derivatives, according to the peculiarity of growth just explained, would not undergo any separation but would retain their embryonic positions. Hence, if the material from which both scutes and plates arise were modified by any local influence, the resultant scutes and plates would be found together, as in the first abnormal specimen described. In the posterior part of the carapace, on the other hand, the ectodermic migration would be excessive and any early local disturbing influence that affected both scute and plate-producing tissue would leave its trace in the adult in the form of a region of modified scutes posterior to a region of modified bony plates, — a condition realized in the second abnormal specimen. Thus, from what is known of the methods of growth of the integument and subjacent parts in vertebrates, it is fair to assume that the abnormalities of scutes and bony plates in the second specimen, though separated in the adult, may be as truly correlated as those of the first specimen, in which the modified areas still remain superimposed.

The older anatomists have very generally pointed out the superficial resemblances between the scutes and the bony plates of the chelonian carapace, but they have as a rule denied any close relation between these two sets of structures. Gegenbaur (**'98**, pp. 132, 174), in his recently published volume

on the comparative anatomy of vertebrates, repeatedly emphasizes the idea of the independence of scutes and bony plates. The conclusions to which the present studies lead do not favor this view, but lend support to the opinion expressed in cautious terms by Goette ('99, p. 430), and more radically by Gadow ('99), to the effect that in primitive turtles each bony plate was associated with a single scute. Supposing such relations to have existed, it is easy to conceive how the present conditions could have been brought about; for, if the migration of the ectoderm were to be so retarded as to take place after its division into scutes, the posterior scutes would be carried away from the bony plates to which they belonged, and in consequence of crowding some of them might be suppressed, with the result that a carapace with a given number of bony plates would be covered by a smaller number of scutes. Although such an explanation of the present condition of the chelonian carapace must be tested by experiment, the evidence derived from the study of the abnormal specimens described above shows that there is a closer relation between bony plates and scutes than has been generally admitted heretofore.

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THREE POLYMELOUS FROGS.

ROSWELL H. JOHNSON.

HAVING found three undescribed polymelous frogs in different American museums, it occurred to me that the newly discovered method of skiagraphy might give an opportunity for the study of these cases without dissection, which is usually not permissible with museum abnormalities. The accompanying plates give the result of that work.

Case I (Figs. 1, 5, 6, and 7), a *Rana palmipes*, which had not yet lost its tail, is from the collection of the Harvard Medical School. This specimen bears two supernumerary limbs arising from the right and left scapular regions. Of these the one on the left is inferior in size to the normal leg of that side and is entirely free from it. It is peculiarly devoid of pigment. In the skiagraph (Fig. 5) a small rod-shaped bone, answering to a clavicle or coracoid, is to be seen extending from the head of the humerus of the supernumerary leg on the left to the skull. The humerus extends past its joint with the radio-ulna in a cartilaginous projection. The formation of the hand is apparently normal. The ulnar side is the more ventral and anterior. The supernumerary leg of the right side is represented by a mere stump, as some previous investigator has cut off most of the limb. This arises from the scapula, which is enlarged and misplaced on this side.

Case II (Figs. 3, 4, 8, and 9) is a young *Rana halecina* Dum. and Bibr., which was collected by Mr. Carlos E. Cummings on vacant land in the city of Buffalo. It is now loaned to the Buffalo Society of Natural Sciences. Directly above the left hind leg arises a supernumerary leg with nearly normal markings. In size this is but slightly less than the normal legs, the reduction being greatest in the phalanges. The head of the extra leg does not fit into an acetabulum, although it lies close to the position where its acetabulum would be. The left ilium

divides about one-third of the distance from the anterior end. The normal leg of the left side is connected with the more ventral and mesal of the two parts, as would be natural from its position. The dorsal part is apparently free from the pubis. The distal extremity of the tibio-fibula appears to have three terminal enlargements instead of the normal two. Three bones of about the same size replace the normal astragalus and calcaneum. Eight bony elements align themselves in the position of the metatarsals, one group of six, with two very much smaller ones at some distance. Three phalanges arise from the terminal metatarsal of the more strongly developed end and one from the next metatarsal. This structure certainly bears out Bateson's statement : "In the enormous majority of polymelians the extra repetition consists of parts of a complementary pair."

Case III (Figs. 2, 10, 11, 12) is another young *Rana halecina* Dum. and Bibr., in the anatomical collection of the University of Chicago, which from an accompanying note seems likely to have been found in the immediate vicinity. The coloration of the body is somewhat abnormal, in that the spots are smaller and more numerous than is usual. Directly ventral to the right fore leg, which is slightly displaced dorsally, and is smaller than the normal leg of the other side, is a peduncle from which two legs arise. These are each about the size of the left normal leg and distinctly larger than the normal leg of the right side. Each of the supernumerary legs seems normal in its parts and has the usual blotches. The ulnar aspects face each other. The skiagraph reveals two fused bones in the cone-shaped projection (indicated by asterisk) between the supernumerary legs. It seems to me that we must regard each of the halves of the outgrowth as again double, the internal member of each pair having developed from pressure and juxtaposition into these two fused bones in the cone-shaped projection. This seems likely from the analogy in abnormalities of crustacean appendages, such as that shown in Fig. 182, IV, in Bateson's *Materials for the Study of Variation*, which is taken from Maggi. In the cases cited of duplicity of appendages already of a double nature, the two median elements fuse

and remain comparatively undeveloped. Should my interpretation be correct, we have in this frog a hitherto undescribed degree of polymely.

I wish to express my thanks to Dr. C. B. Davenport, under whom this work was done.

HULL ZOÖLOGICAL LABORATORY,
February 17, 1900.

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PLATE I.

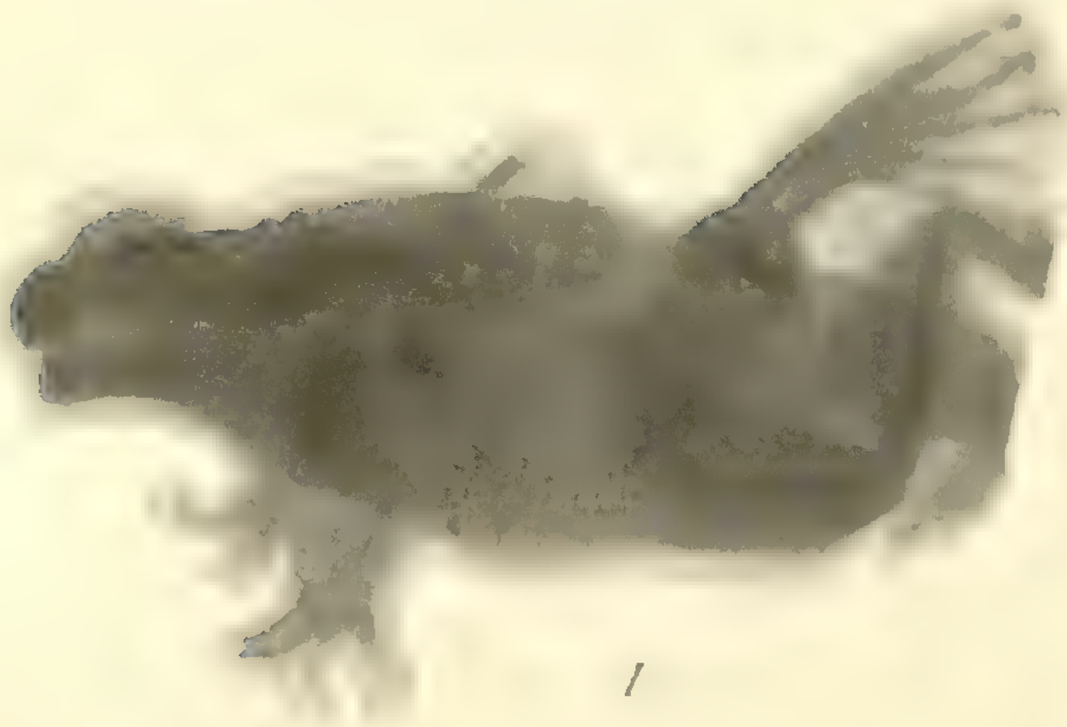
FIG. 1. Case I. Skiagraph taken with the frog's left side bearing the entire supernumerary leg closer to the plate.

FIG. 2. Case III. Ventral side closer to the plate, and legs so arranged as to be as much as possible in a transverse plane to the direction of the rays.

FIG. 3. Hind legs of Case II arranged to show the bony elements of the supernumerary leg.

FIG. 4. Case II. Dorsal side of pelvis closest to the plate. Anterior portion of the body projected far above the plate.

FIG. 5. Case I. Back closer to plate. Plate and frog were inclined to the course of the rays, so that image of the supernumerary leg would fall anterior to the normal legs.



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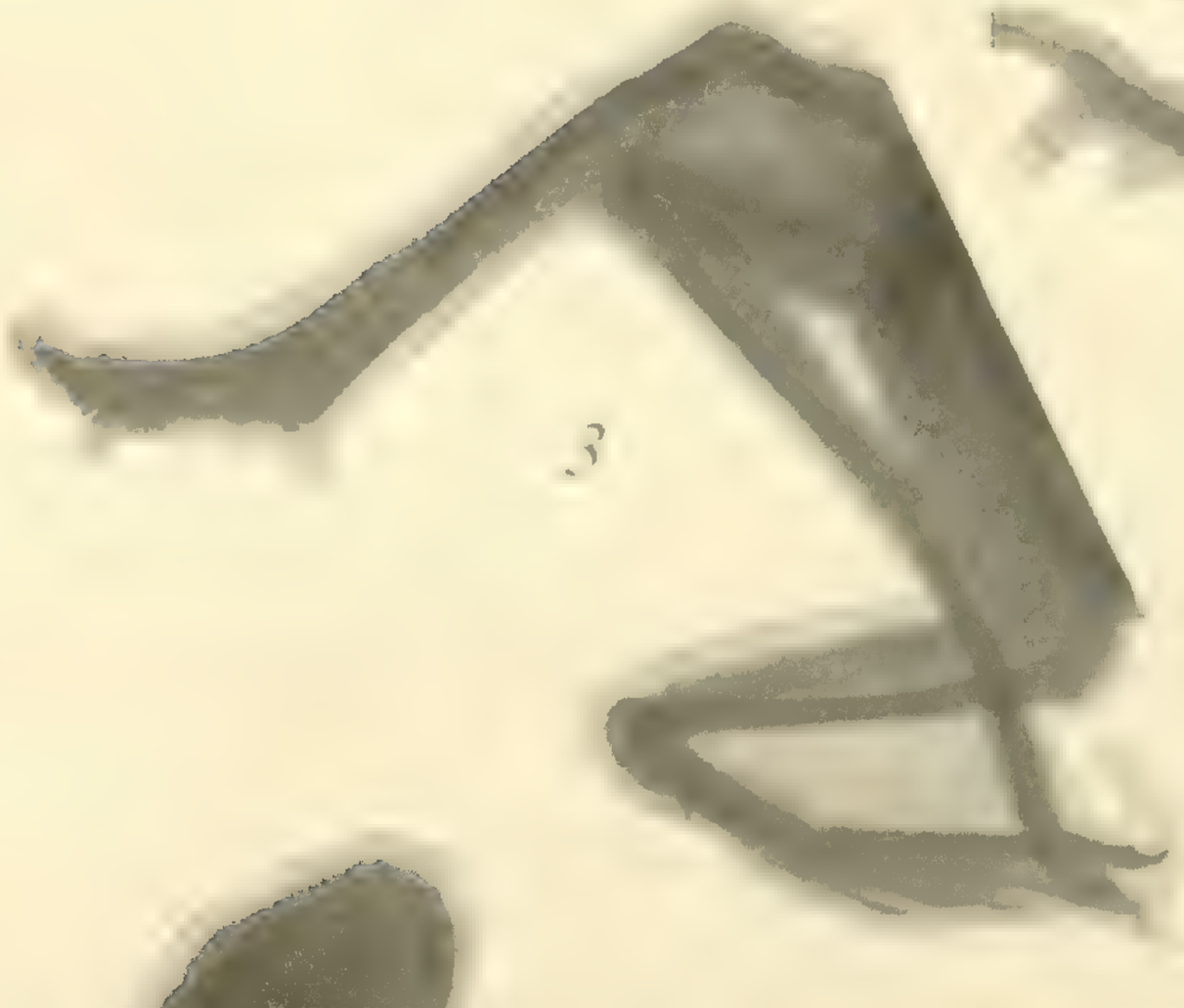

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PLATE II.

FIG. 6. Left side view of Case I.
FIG. 7. Right side view of Case I.
FIG. 8. Posterior view of Case II.
FIG. 9. Dorsal view of Case II.
FIG. 10. Anterior view of Case III.
FIG. 11. Side view of anterior part of Case III.
FIG. 12. Diagram of the toes of the extra legs of Case III.

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SOME CASES OF SALTATORY VARIATION.

CARL H. EIGENMANN AND ULYSSES O. COX.[1]

SOME specimens showing saltatory variation have been collected at various times for the museum of the Indiana University. It is the purpose of the present paper to place these on record.

1. A remarkable case of meristic abnormality was collected near Harrodsburg, Ind. The specimen is a male of the common frog, *Rana pipiens* Schreber, 54 mm. long, and shows the following characters (Fig. 1) :

The forearm and hand of the right side are duplicated. The extra part arises just behind the normal arm and passes inward and forward to below the eye of the left side. It is 19 mm. long from its origin to the base of the fourth finger and 2 mm. in diameter. The normal right forearm is 12 mm. long and 5 mm. thick. Its striking and unique feature is the band of skin through which it passes, and which holds it as a sling. This band is well represented by the photograph, and is 4 mm. wide. The supplementary arm and wrist are so placed that the fourth finger occupies the posterior place. The second, third, and fourth fingers are as in the normal hand, but more slender. Separated from these there are, in the place of the first finger, two fingers, of which the first is the longer. The free portions of the five fingers measure respectively 4, 2, $3\frac{1}{2}$, 5, and 3 mm. On the anterior margin of the base of the first finger there is a broad callosity.

On the lower surface of the lower jaw, below the left eye, there are two tubercles, the posterior one the longer, measuring $1\frac{1}{2}$ mm. in height. There are no other indications of abnormalities.

The variation here recorded may be classed with pathological abnormalities rather than with variations that lead to the mutation of species.

[1] *Contributions from the Zoölogical Laboratory of the Indiana University*, No. 38.

2. The second case is of much greater interest. It is a specimen of *Ameiurus natalis*, 120 mm. long, from Turkey Lake, Ind. It differs from normal specimens in the absence of all traces of ventral fins. There are no scars to indicate

FIG. 1.—Ventral view of *Rana pipiens*, with supplementary arm.

that the fins might have been lost as the result of a wound, and we may safely assume that in this specimen we have a case of saltatory variation which is perfectly bilateral. Such a variant, if its characters should be slightly prepotent, would give rise to a race of individuals without ventral fins, which, in nature, would readily be recognized by naturalists as a distinct

genus. It is possible that some of the genera of fishes without ventrals have arisen from such prepotent variants, a supposition that is reinforced by the following case of variation.

3. The variation of greatest importance to be recorded here was found in nine specimens of *Ameiurus melas*. These were collected at random, out of a lot that must have numbered fifty or more, in a small cave at Glasgow, Ky. The fact that the specimens showed a remarkable series of variations was not detected until after they had been brought to the laboratory, so we can safely assume that they were collected at random and not with respect to the variations to be recorded. The

FIG. 2. — *Ameiurus melas*, showing supplementary narial barbels (see directive lines).

specimens seen in the cave were all of approximately the size of the individuals here recorded. Unless they represent a dwarf race living in the small brook in this cave, they are probably of the same age. One of us visited this cave two years ago, and he neither remembers to have seen any catfishes in the cave stream at that time, nor are any specimens in the collection made at that time. While the fact that he does not remember to have seen them and did not collect any two years ago is not conclusive evidence that there were no catfishes in the cave at that time, the size of the specimens, taken together with this, makes it probable that the present specimens are under two years old and got into the cave either as a batch of eggs or during their schooling stage. It is well known that the young of the catfishes remain together as a school for

many days after hatching. It is not probable that they migrated into the cave as separate individuals, unless they came from a source as limited in extent as the cave itself. Specimens migrating from a more extensive source would, under no probability, show the similarity of variation to be here recorded.

In common with all the other North American fresh-water catfishes, *Ameiurus melas* is provided with a barbel in front of each posterior nasal opening. In the specimens under consideration there are usually one or more additional barbels behind the first, frequently on the anterior lip of the nasal opening. These barbels in detail are as follows, all measurements being in millimeters[1]:

Number of Specimens.	Length.	Length of the Left Nasal Barbels and the Supplemental Ones.	Length of the Right Nasal Barbels and the Supplemental Ones.
1	110	$\frac{2-4^{a}}{1}$, **15**, 6	**16**, 1[b] (Fig. 2 *A*)
2	86	$\frac{4-4^{c}}{1}$, **12**	**11**, 7.9 (Fig. 2 *B*)
3	78	**11**[d]	**11**, 2
4	78	**11**, 6	**11**, 4 (Fig. 2 *C*)
5	78	**11** and small lobe	6, **10**, 2
6	76	**11**, $\frac{2\frac{1}{2}-2^{e}}{1}$	**11**
7	74	minute, **11**, 3	minute, **11**, 1½
8	74	**10**, minute	**10**, lobe on narial lip
9	78	**11**, 1	**10**, 1

[a] On the left side there are two supplemental barbels. One behind the inner edge of the main barbel is 6 mm. long. One behind the outer edge is T-shaped. The basal segment is but 1 mm. long. The upper segment slants from behind upward and forward. Behind the basal segment it is 2 mm. long, the portion in front 4 mm.

[b] Placed on the edge of the narial lip.

[c] The supplemental barbel is Y-shaped, with the basal segment 1 mm. long, the distal segments each 4 mm., and placed on the edge of the narial lip.

[d] Here there are two lobes on the narial margin, but no distinct development of barbels.

[e] Y-shaped, with a basal segment 1 mm. long, and distal segments respectively 2½ and 2 mm.

[1] In the columns of lengths the figures representing the lengths of the various supplemental barbels are placed in the same relation to the length of the main barbel as the supplemental barbels are placed to the principal barbel.

The length of the normal barbel is indicated in the table by heavy figures.

Summarizing these data, we get the following:

Number of cases with two barbels: left, 3; right, 2.
Number of cases with one barbel: left, 6; right, 7.
Number of cases with a Y or T shaped barbel: left, 3; right, 0.
Number of cases with no supplemental barbel: left, 0; right, 1.
Number of cases with one on the left and none on the right, 1.
Number of cases with one barbel on each side, 4.
Number of cases with two barbels on each side, 1.
Number of cases with two barbels on the left and one on the right, 2.
Number of cases with one barbel on the left and two on the right, 1.

Total length of all supplemental barbels, not counting minute lobes, ΣV: left, $37\frac{1}{2}$; right, $24\frac{1}{2}$.

Average variation, $\frac{\Sigma V}{N}$: left, 4.166; right, 2.722.

While it is difficult from the variety of elements (number, length, shape) that enter into each variation to make a direct estimate of the degree of variability of each side and the degree of correlation of the variation of the two sides, the number of individuals is so small that an approximation can be arrived at by a glance at the data.

The left side is much more variable than the right.

The presence of barbels on the two sides is an indication of bilateral correlation. This is reinforced by the fact that in five out of nine cases the number of barbels on the two sides is the same. It would seem that the left side is leading in the addition of barbels, in spite of the fact that in one specimen no supplementary barbel is found on this side.

Admitting, in the absence of evidence to the contrary and strong probability in its favor, that the specimens belong to one brood, or, at the very least, that the specimens occupying the narrow limit of environment in which they are found are

genetically related, we may deduce some interesting conclusions from the preceding data:

1. The variation here recorded is saltatory.
2. It is bilateral, without reaching perfect bilateral correlation. This makes it probable that primarily the variation was introduced or induced by changes on one side. Judging from its greater variability, the left side was primarily concerned.
3. It is improbable that the variation originated independently in each of the specimens.
4. The variation probably arose in one of the ancestors of the specimens.
5. Admitting 4, the saltatory variation arising in an ancestor was prepotent to a very high degree.

There are entirely too many probabilities in these conclusions, in spite of the fact that the probabilities all verge nearer certainty than uncertainty. The matter of the prepotency of the variation can readily be determined by breeding some specimens from the cave with normal specimens, which will be attempted.

THE LARVAL COIL OF BACULITES.

JAMES PERRIN SMITH.

Historical. — The genus Baculites is widely distributed in Cretaceous rocks, found in almost every region, and the straight shafts of this form are locally among the commonest fossils. But in nearly all these places only the straight, incomplete specimens are found; so that until a few years ago Baculites was supposed to be an ammonite that had reverted to the orthoceran form. About ten years ago, however, Dr. Amos Brown discovered in the Cretaceous beds of Dakota a number of young specimens of *Baculites compressus*, with a larval coil attached to the straight shaft; this he rightly interpreted as indicating the descent of Baculites from a coiled ancestor.

Until recently the larval coil of Baculites had been found only at this single locality near Deadwood, Dakota; but during the past year the writer discovered a number of larval coils of *Baculites chicoensis* Trask in the lower Chico beds, Upper Cretaceous, on the Arroyo del Vallé, about eight miles southeast of Livermore, Alameda County, California. Many of the specimens are perfectly preserved, some with the shell on and others in clear, transparent calcite casts, showing the development and the specific characters as well as when the animal was alive. In order that the early stages of the shell should be preserved the animal must have died in early youth, for the test is too thin and delicate to have remained uninjured while attached to the larger shell, and not protected by it. All specimens more than a few millimeters in length are found with the small end broken off, as it could not have been of any use to the animal.

A peculiarly fine sediment is necessary for the preservation of these fragile forms, and they were found only in calcareous nodules, where the amount of lime in the clay prevented the dissolving of the calcite of the shells, and where rapid hardening

prevented their decaying or being ground up by the waves. The young must have flocked together in quiet nooks where the water was clear and where there was little grinding by wave action on sands or pebbles. Such concurrence of circumstances must necessarily be seldom found, and it is not surprising that these delicate forms have been found in only two localities in the world.

Retardation in Baculites. — This genus has always been taken as a type of reversionary forms, since, although it descended from coiled ancestors, at maturity it resembles Orthoceras in its straight shell. It is, however, not really reversionary, for the septa are not orthoceran, nor even nautilian; they are ammonitic and complex, and grow more so towards maturity, after passing through a goniatite stage in early youth. The shell cannot, then, be said to have reverted to the stage of Orthoceras nor even of Bactrites; but it is clearly a degenerate, retrogressive form, retarded in most characters, while progressive in others. Its septa fail to reach the degree of complexity attained by its not very remote ancestors; the number of lobes and saddles is reduced, and the goniatite stage is prolonged, the ammonitic stage being reached later in life than was the case with its immediate ancestors.

But even this reduction of the elements of the septa responds to the law of tachygenesis and is pushed back in the ontogeny, so that in the earliest larval stages the full number of lobes and saddles is never present. Also the early straightening out of the spiral coil is progressive degeneration from a lytoceran form. In the genus Lytoceras it has often been observed that in old age the body chamber leaves the spiral a little way, and Baculites is merely a case of inherited senile degeneration, pushed back in individual ontogeny until the retrogressive characters appear at successively earlier stages of growth, reaching finally the larval stages. This is necessarily followed shortly by the extinction of the race.

In all normal ammonites the siphuncle begins in the embryonic protoconch with a cæcum or bulbous enlargement, which never appears in later stages. Baculites shows retardation in its development by a repetition of the siphonal cæcum in several

chambers of the larval coil, indicating a persistence of embryonic characters. This persistence of the siphonal cæcum is seen in the young of *Lytoceras alamedense*[1] from the same locality, and it is interesting to note that this species of Lytoceras shows degeneration also in the development of its septa; the genus normally has its lobes triænidian (three-pointed) in the early adolescent stages, while at maturity they always become dicranidian (divided into two sections); but *L. alamedense* never has triænidian lobes, they being dicranidian at the beginning of the adolescent stage. In Lytoceras we have an early inheritance of a mature character, and in Baculites a similar prematurity of development, but accompanied by greater retardation. In *Lytoceras alamedense* the septa become ammonitic at one and five-twelfths coils, diameter 1.87 mm., while in *Baculites chicoensis* the septa persist in the goniatite stage until the shaft has extended two and a half millimeters from the larval coil, corresponding to nearly two revolutions if the shell had been coiled continuously in a spiral.

Another mark of retrogression is the contraction of the whorl in the latter part of the larval coil; in the early stages the whorl increases normally in size, but at about three-fourths of a revolution begins to contract, until where the shaft leaves the coil it is much more slender than the embryonic or earlier larval whorl, and does not attain its former size until it has grown some distance beyond the coil. Contraction or abnormal shape of later whorls in ammonites has been shown by J. F. Pompeckj[2] to be a manifestation of degeneration, and to be accompanied by an early extinction of the race. In Baculites we find the contraction of the chamber pushed back by tachygenesis into the larval stage, and a profound degeneration otherwise shown; from the geological history of the race we know that its life was short and that extinction speedily followed upon this unnatural development of the shell.

Ontogeny of Baculites. — At maturity *Baculites chicoensis* consists of a straight shaft, slightly tapering, with an ovoid

[1] Smith, J. P. *Proc. Cal. Acad. Sci.*, third series, Geology, vol. i, No. 4, Pl. XVI, Fig. 5.

[2] *Die Ammonoideen mit Anormaler Wohnkammer.* 1894.

cross-section. The surface is corrugated with wrinkles or curved ribs parallel with the striæ of growth, forming a ventral, shovel-like extension of the aperture. The septa are complex, consisting of a divided ventral lobe, two pairs of laterals, and a short dorsal lobe. These resemble the septa of Lytoceras, but are simpler in digitation and number of lobes and saddles. Specimens of the mature shell are known nearly a foot in length, with scarcely any tapering of the form, so that the extreme size of maturity or old age must have been considerably greater than this.

The phylembryonic or protoconch stage is very much like that of all the other angustisellate ammonites, except that the spheroid tends to become more angular, and the internal septum begins to show traces of lobes and saddles. The siphonal cæcum is unusually large, and was seen to be within that part of the protoconch cut off by the first septum. The limits of the embryonic body chamber were plainly seen on several specimens, marked by a constriction between the first and second septa, but not following the outline of either; the diameter at this stage was 0.53 mm. (Fig. 5).

The next step in growth was the formation of the cæcum, followed very soon by the development of the first septum; this marks the beginning of the larval stage, as shown in Figs. 3 and 5. The body chamber of the first or ananepionic larval stage consisted of an entire revolution; thus the metamorphosis of the young animal must have been considerable. The surface of the shell in the phylembryonic and ananepionic stages was covered with pustules, giving a granulated appearance to it; but at the end of the first revolution these pustules ceased sharply at a constriction, and gave place to cross striæ and ribs (Figs. 12 and 18).

The second septum, which marks the beginning of the metanepionic stage, has a divided ventral lobe, and the full number of lobes and saddles that the animal possessed throughout life; the later changes consisted merely in the gradually increasing digitation of the septa, which, however, persisted in the goniatite stage not only throughout the entire coil, but also for two and a half millimeters of the straight shaft (Fig. 6).

The metanepionic or second larval stage is characterized by the sudden change in sculpture which takes place at the end of the first revolution, where the pustules are replaced by fine cross striæ and ribs parallel with these (Fig. 18). This stage may be arbitrarily considered to last as long as the coil continues, but the spiral widens and at a quarter of a revolution beyond the constriction the shell leaves the coil and grows out nearly straight. With this the paranepionic stage may be considered to begin, and to continue so long as the septa are goniatitic; at the distance of two and a half millimeters from the coil the septa begin to become ammonitic, and the larval stage ends (Figs. 19 and 20). The impressed zone continues in the shaft for nearly a millimeter from the coil, but before the paranepionic stage has ended the cross-section of the shaft becomes rounded instead of semilunular. The larval shell seems to be always unsymmetric, at least in the large number of specimens studied, and this lack of bilateral symmetry was not due to crushing, but actually to one-sided growth. The writer has observed that this is quite common in degenerate forms of ammonoids, while progressive species with normally healthy growth are exceedingly symmetric and constant in development.

The digitation of the septa, which begins with the indentation of the first lateral saddle at about two and a half millimeters from the coil, marks the beginning of the adolescent or neanic stage. The complexity of the septa increases slowly at first, but soon becomes more rapid as the whorl begins to be compressed laterally, which takes place at about eighteen millimeters from the coil. This lateral compression may be regarded as the beginning of the metaneanic or second adolescent stage, which, however, cannot be sharply differentiated from the others. The angle of increase of size of the whorl throughout the later larval and earlier adolescent stages is considerable, but at the distance of about thirty millimeters from the coil the angle becomes smaller, indicating a distinct change in the rate of growth. This may be called the last adolescent or paraneanic stage, and forms a gradual transition to mature conditions of growth. No sharp line of demarcation exists,

but for convenience the adult or ephebic stage may be said to have begun when the compressed form, the greatest complexity of septa, and the rough sculpture of maturity are visible. This is the case at the distance of about seven centimeters from the larval coil, when the animal has by no means attained to mature size. Further growth is then only increase in size and not progression of development. Old age, or the gerontic stage, shows itself in the obsolescence of sculpture and of the increase in size. Only a few specimens showing senile degeneration were found, which is not surprising if we consider the small chance any of the lower animals have of becoming old.

Phylogeny of Baculites. — This genus has usually been classed as an aberrant form under the Lytoceratidæ, but E. Haug [1] says that the resemblance of the adult septa of Baculites to those of Lytoceras is accidental; that Lytoceras in youth always has triænidian (three-pointed) septa, while Baculites is always dicranidian (two-pointed). But the writer [2] has recently described the development of a somewhat degenerate species of Lytoceras, in which the septa are two-pointed in the earliest adolescent stage. This observation removes the objection to the commonly accepted derivation of Baculites, and is especially interesting in view of the fact that Lytoceras in its old age often leaves the coil a little way. The young stages of the species of Lytoceras studied by the writer are almost exactly like those of *Baculites chicoensis*, the latter showing only a greater contraction of the larval chamber, a premature ornamentation of the embryonic and larval shell, and a reduction of the number of lobes and saddles. The only other studies on the development of this genus have been made by Dr. Amos P. Brown [3] on *Baculites compressus*. As compared with that species, *Baculites chicoensis* shows greater degeneration, for it leaves the spiral at the end of one revolution, while

[1] Les Ammonites du Permien et du Trias, *Bull. Soc. Géol. France*, 3e sér., vol. xxii, p. 410, 1894.

[2] The Development of Lytoceras and Phylloceras, *Proc. Cal. Acad. Sci.*, third series, Geology, vol. i, No. 4, 1898.

[3] On the Young of Baculites Compressus Say, *Proc. Phil. Acad. Nat. Sci.*, 1891, pp. 159, 160; and The Development of the Shell in the Coiled Stage of Baculites Compressus Say, *Proc. Phil. Acad. Nat. Sci.*, 1892, pp. 136–141.

B. compressus has two revolutions in its coil. But the development of the two species is essentially the same, and the genus is monophyletic, in so far as observations on two species can demonstrate it. Dr. Brown thought that the larval stages of Baculites showed analogy with those of Crioceras and Ancyloceras, and none with Scaphites. In all probability, however, all three of these genera are polyphyletic, and have originated from several stocks. Some species of Scaphites seem to come from a Hoplites-like ancestor, but in studying the development of some undescribed Scaphites from the upper Cretaceous of southern Oregon the writer found their larval stages to be very like those of Lytoceras and Baculites, and they probably have a common origin.

Straight degenerate forms have appeared in the history of the cephalopods from time to time, from the Trias upward, not from any one stock in particular, and not genetically connected. The mere fact that the form is abnormal is no indication whatever of kinship. In each case they spring from normal forms and indicate their origin in their normally coiled young. Naturally it is seldom that transitional forms from the progressive to the degenerate are known, for the beginnings of these transitions are regarded as mere freaks of some normal species. Further, degeneration or retardation is not necessarily accompanied by abnormality of form, as has been shown by the writer in the case of *Lytoceras alamedense* and in the development of Placenticeras,[1] where the genus is still progressive in many characters. Whether normal or abnormal in shape these degenerate forms are always short lived, for they represent the extreme specialization of which the group is capable, while the more primitive stocks or radicles persist through very long periods, often little changed, but from time to time giving rise to the abnormal forms as side branches. These side branches coming off from the parent stock at no great distance in time from each other may give the semblance of a genetic series, but this is usually deceptive. It is thus supposable that some of these forms have originated from the parent stock from

[1] The Development and Phylogeny of Placenticeras. *Proc. Cal. Acad. Sci.*, third series, Geology, vol. i, No. 7, 1900.

different species and at different times, in which case the genus would still be strictly monophyletic. But in the case where the resemblance is merely that of shape and not of development, as in the several species of Scaphites, the genus is not monophyletic, and the forms of which the development is different from that of the type cannot strictly be placed in that genus.

Baculites probably originated from Lytoceras, but it is not at all likely that all species of Baculites came from the same parent Lytoceras, nor, indeed, in the same region, for this degenerate form is too widely distributed and too short lived geologically for this to be probable. This supposition would presuppose for Baculites means of distribution surpassing those of the other invertebrates, which we know could not have been the case, for they were not pelagic forms, but shore dwellers, and individual species are no more widely distributed than the gastropods and pelecypods that are associated with them.

STANFORD UNIVERSITY, CALIFORNIA.

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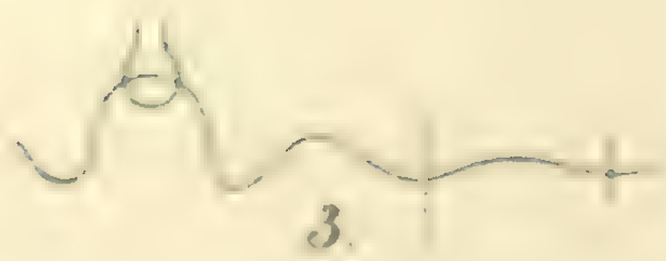

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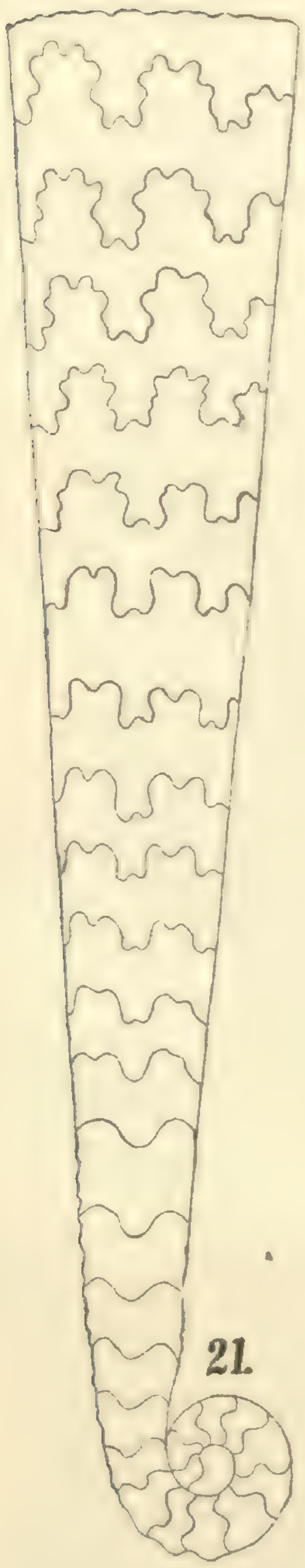
PLATE A.



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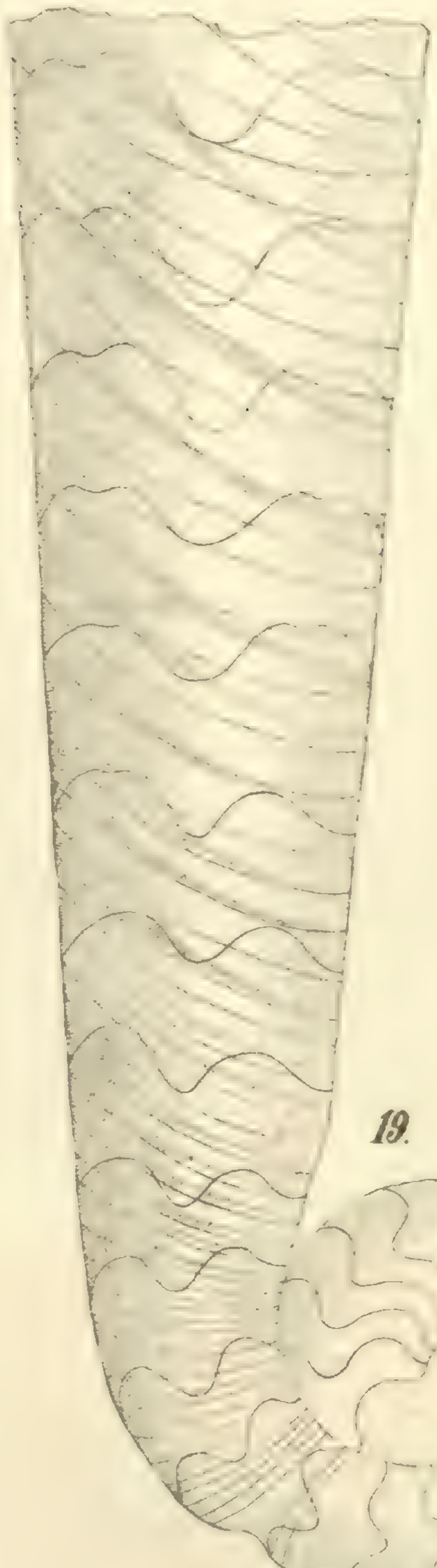

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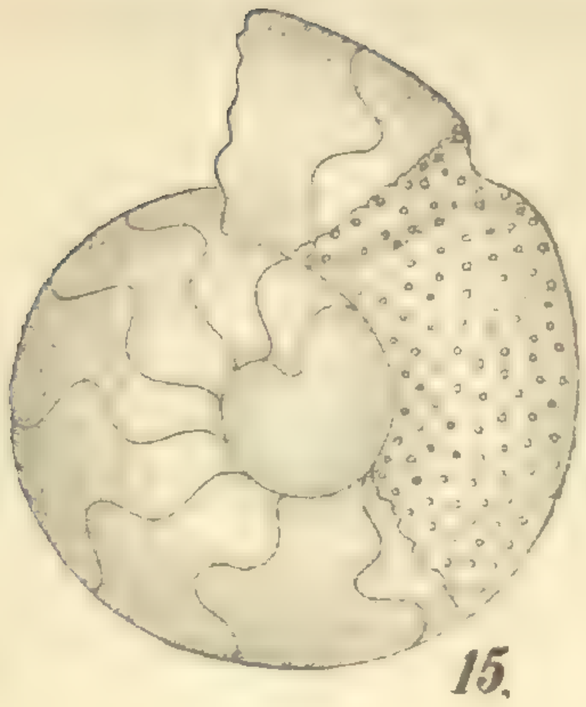

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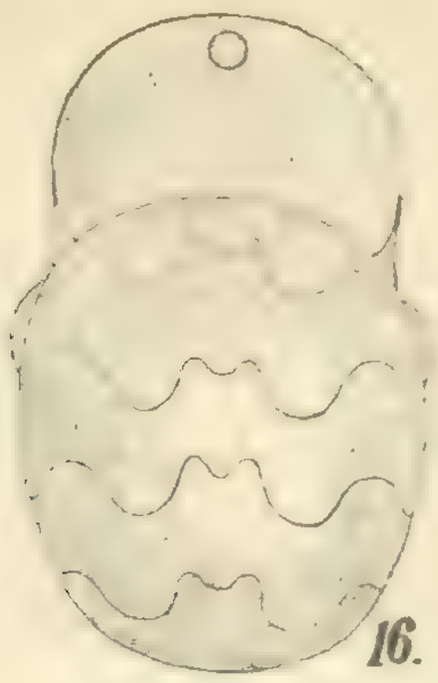

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PLATE B.

EXPLANATION OF PLATES.

The Development of the Larval Coil of *Baculites chicoensis* Trask.

FIGS. 1 and 2. Protoconch, front and top view, diameter 0.48 mm. Thirty times enlarged.

FIG. 3. First or ananepionic septum, showing the siphonal cæcum.

FIGS. 4 and 5. Larval shell at one-fourth coil, diameter 0.58 mm., showing the ananepionic and metanepionic septa, and the embryonic constriction. Thirty times enlarged.

FIG. 6. Second or metanepionic septum, at one-fourth revolution, diameter 0.58 mm.

FIGS. 7 and 8. Larval shell at one-half coil, diameter 0.68 mm. Thirty times enlarged.

FIG. 9. Sixth septum, at one-half revolution.

FIGS. 10 and 11. Ananepionic shell, showing the embryonic constriction, the ananepionic septum, the siphonal cæcum, and the first larval body chamber. The young animal died before further development took place. Thirty times enlarged.

FIG. 12. Ananepionic shell, showing ornamentation of the embryonic and early larval shell, and the ananepionic body chamber. Thirty times enlarged.

FIGS. 13 and 14. Metanepionic shell at three-quarters of a coil, diameter 0.83 mm., showing contraction of the later chambers.

FIGS. 15 and 16. Shell at end of the metanepionic stage, diameter 1.06 mm., one and one-eighth coils. Thirty times enlarged.

FIG. 17. Metanepionic shell, diameter 1.00 mm., showing periodic swelling of the siphuncle, indicating a retardation of the phylembryonic siphonal cæcum. Thirty times enlarged.

FIG. 18. Larval coil attached to the straight shaft, showing all the stages from phylembryonic through the paranepionic, and the beginning of the adolescent or neanic stage. Ten times enlarged.

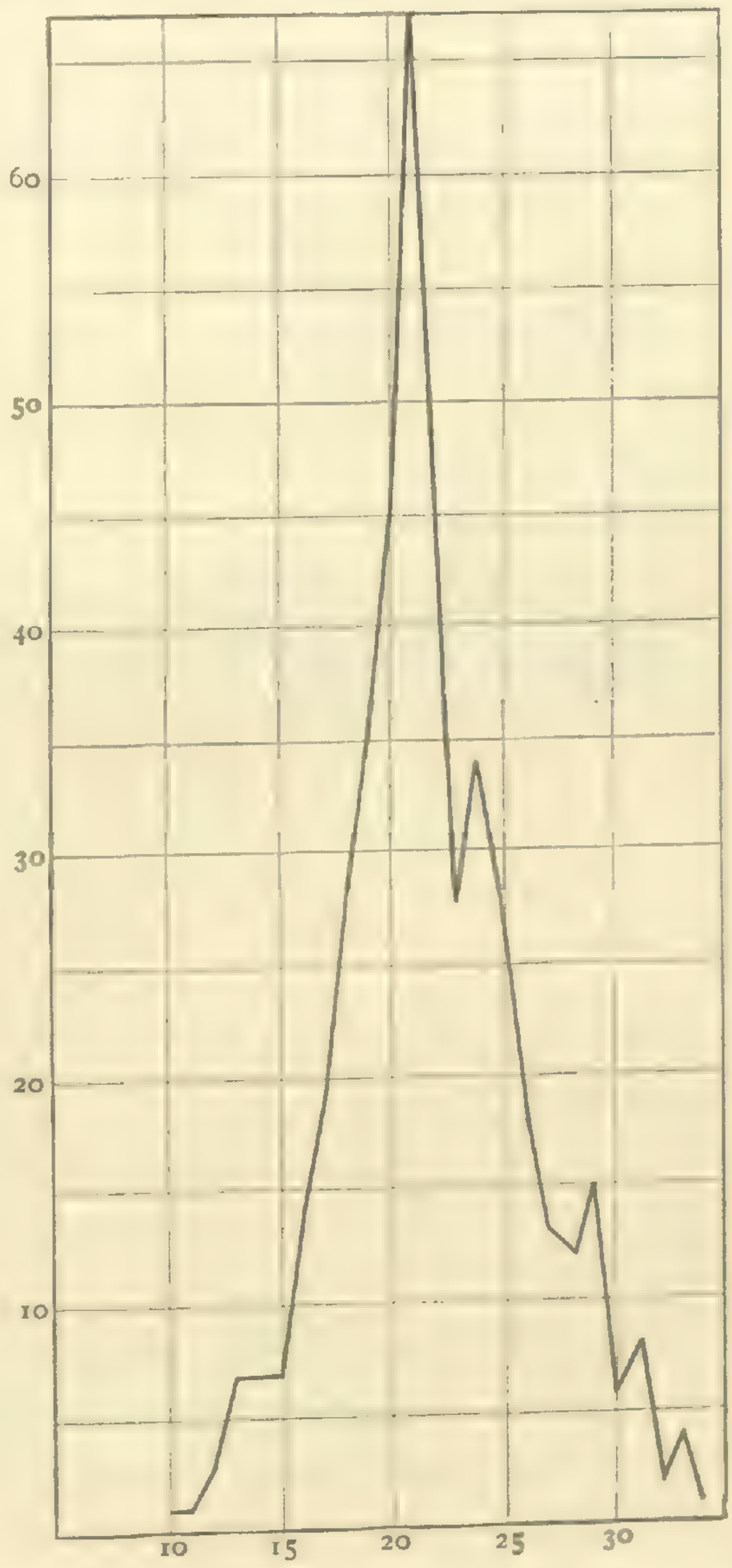
FIGS. 19 and 20. Front and side view of a metaneanic shell, showing the unsymmetric shape of the larval coil, and the contraction of the metanepionic body chamber. Thirty times enlarged.

FIG. 21. Composite specimen, drawn from several pieces, showing the development of the septa from the ananepionic into the adolescent stage. Ten times enlarged.

Mo. Bot. Garden,
1902.

VARIATION NOTES. — Nos. 1–3.

1. *Frequency Curve of White Daisy.* — Mr. F. C. Lucas, of the Englewood High School, Chicago, who published a paper on "Variation in Ray Flowers of the White Daisy," in the *American Naturalist* for 1898, has sent us counts made on 444 white daisies collected along the roadside at Northwood, New Hampshire. The results are given in the accompanying curve, where the number of rays (the class) is indicated by the figures at the bottom, and the number of individuals occurring in (the frequency of) each class is indicated by the vertical scale.



The curve is compound. The principal mode is at 21, where Ludwig found it for European individuals. Secondary maxima occur at 13, at 24 (= 3 × 8), and also at 29 and 31. What the latter maxima mean is uncertain; Mr. Lucas calls attention to the fact that they occurred in his specimens from Massachusetts also. We shall be glad to publish the results of counting lots of 1000 to 2000 terminal flowers (only one from each plant) from each of various localities.

2. *Variation in the Branchial Filaments of Aquatic Lepidoptera Larvæ.*[1] — The larvæ of the Pyralid *Paraponyx obscuralis* from the Illinois River at Havana have just [always?] 100 branched branchial filaments (gills) arising from the dorsum of the middle segments. The number of branches to a gill is modally different for the different gills, and for the corresponding gill in successive moults. In each gill of the full-grown larva, however, the number of branches is subject to individual variation. The following table gives the modal number of branches for each gill of the full-grown larva.

Segments.	*a.s.*[2]	*p.s.*	*a.i.*	*p.i.*	*ped.*
2	6	5	3	5	6
3	6	5	3	5	6
4–7	4	6	4	5	5
8–10	4	6	4	5	4
11	4	6	4	5	
12				3	

3. *Inheritance in Tailless Cats.* — A female Manx cat (with rudimentary tail) had six litters by normal male cats. In these litters the number of abnormal (Maternal type) and of normal (Paternal type) kittens was as follows:

Litter 1	1 *M*
" 2	5 *M* + 1 *P*
" 3	3 *M* + 2 *P*
" 4	1 *M* + 2 *P*
" 5	1 *M* + 3 *P*
" 6	3 *M* + 2 *P*
	14 *M* + 10 *P*

The maternal (Manx or abnormal) quality was prepotent. Also, there was a loss of this prepotency in the later litters. Was this due to telegony? — R. Anthony in *Bull. Soc. d'Anthrop. de Paris*, 4 sér., vol. x, p. 303, 1899.

[1] Hart, C. A. On the Entomology of the Illinois River and Adjacent Waters, *Bull. Illinois State Lab. Nat. Hist.*, vol. iv, 149–273, 1895.

[2] *a.*, anterior; *p.*, posterior; *s.*, suprastigmal; *i.*, infrastigmal; *ped.*, pedal.

EDITORIAL COMMENT.

Pseudoscience. — The leading article of a recent issue of *The Forester*, entitled "On the Possible Effects of the Gypsy Moth on American Forests," is noteworthy as containing a number of far-fetched conjectures that are dangerously near charlatanry. The following quotation will more than substantiate our statement: "It is not unlikely that some of the curious alterations in the distribution of forest trees which geologists have recognized may have been due to the development in former ages of the Gypsy Moth or other like destructive species of insect. Thus in the early Miocene Tertiary Europe was tenanted by a host of arboreal species closely akin to those that now form our admirable American broad-leaved forests. The Magnolias, the Gums and the Tulip trees, etc., were then as well developed in Europe as they are in this country. Suddenly all these species disappeared from the old world. There is no reason to believe that the change was due to an alteration in climate. There are many evidences indeed that such was not the case. It is a very reasonable conjecture that that alteration was brought about by the invasion of an insect enemy which may have been the ancestor of the Gypsy Moth."

Against this "very reasonable conjecture" the words of Dr. Asa Gray may be recalled: "Probably the European Miocene forest was about as rich and various as is ours of the present day, and very like it. The Glacial period came and passed, and these types have not survived there, nor returned."

The statement also "that the naturalist who attained the unhappy success" of introducing the gypsy moth into America did so for the purpose of interbreeding the introduced insects "with various native species of moths, with the expectation of producing a hybrid which would feed on the leaves of our numerous American species of oak and produce a valuable kind of silk," shows an absolute lack of the first essentials of successful hybridization; moreover, it does injustice to a man of pure science whose imagination never rioted with vagaries.

"News" in the American Naturalist. — Owing to the length of time which must necessarily elapse between the preparation of

the manuscript and the appearance of the printed page, the editors have thought it best to drop the department of "News" which has long been a feature in this journal. This step is taken the more willingly since our contemporary, *Science*, covers the same field in so able a manner, and with its weekly issue can present items of news far more promptly than we are able to.

The notices of appointments, retirements, and deaths have been approximately complete ever since the journal passed into its present control. This feature will be retained, not as a matter of news but as a matter of record, and will be presented every three months with the endeavor to have this record as nearly complete as may be.

Another feature which will form part of the record, and which appears for the first time in the present number, is the record of gifts to what may be termed educational institutions, including colleges, technical schools, libraries, and the like. In our present record, which includes eleven months of the year 1900, we note the gifts of over $16,000,000 to these purposes. Scattered through the pages of a weekly or monthly journal these items make but little impression on the reader, but gathered at intervals of six months or a year they are ample evidence of the generosity of our wealthy people and of those who are classed among the "well-to-do." In contrast with this liberality of the moneyed classes of America stands the parsimony of the same classes in the Old World. Gifts of a similar character there are rare. An instance comes before us as we write. During the past year Brown University raised over one million dollars and in this way secured an additional gift of a quarter of a million more. During two years past the University of Cambridge, one of the two great universities of England, has been trying to increase its funds, both for endowment and for new buildings, and in spite of constant efforts it has been able to raise but a little over three hundred thousand dollars (£62,500).

REVIEWS OF RECENT LITERATURE.

ZOÖLOGY.

Hammar's Layer. — Professor Hammar had previously[1] given facts that led him to believe that blastomeres of many animals are connected by a continuous membrane-like expanse of protoplasm that forms the outermost part of each cell and passes over from cell to cell. This cleavage would result in only partial subdivision and not in complete isolation of cells. Moreover, the cleavage cavity would be a hollowed-out interior space, not outside space extending in between the cells.

In a recent paper[2] he advances some new facts and considerations in support of the thesis that this connection of blastomeres is a protoplasmic part of the egg and not a dead "membrane," and. secondly, that it is a primary connection always there, and not a secondary connection established from time to time as are the filose threads previously described by others and now, apparently, seen by Hammar in preserved eggs.

E. A. A.

What holds Blastomeres together? — Curt Herbst[3] adds to his previous work upon the chemical environment of echinoderm eggs and larvæ a series of observations upon eggs in an artificial sea-water free from calcium.

Eggs in various stages of cleavage thrown into such a solution may continue to cleave and even to differentiate so that some cells may show cilia; but the blastomeres do not cohere, but fall apart and develop separately. This, however, takes place only when the eggs have been shaken to remove the membrane, that else holds the cells together to some extent.

When the isolated cells are put back into water with lime they cleave and cohere, so that many little larvæ result from one egg.

The cause of the falling apart of the blastomeres is not clear. Herbst supposes they are normally held together by the tension of

[1] See Review, *American Naturalist*, 1896, p. 597; and 1897, p. 454.
[2] *Arch. f. mikr. Anat.*, Bd. lv. February, 1900.
[3] *Arch. f. Entm.*, Bd. ix, Feb. 20, 1900.

Hammar's layer, the ectoplasmic layer that passes from cell to cell, and that the absence of lime so modifies this membrane as to prevent it from holding the cells together. The actual moving apart of the cells he thinks due to their individual movements. Yet the author grants that some other factor remains for future research to discover, since when cells that have fallen apart in water free from lime come together again and flatten against one another in normal water, there is no normal membrane present.

That one such factor is a pathological state of the ectosarc accompanied by abnormal "filose activities" seems indicated by the author's figures.

E. A. A.

Vitality of Eggs and Sperms. — James F. Gemmill[1] records some interesting observations upon the life of sperm and egg. Sperms of the sea-urchin, *Echinus sphæra*, put into still water, move only seven inches before dying, so that their power of dissemination must depend largely upon currents of water and not upon their own locomotion.

In a tube of 2.4 mm. diameter they ascended 12.6 mm. in 7 minutes; 31.6 mm. in 20 minutes; and 44 mm. in 45 minutes. In tubes of different sizes these sperms ascended a shorter distance in the narrower tubes.

Sperms of an annelid were found to live longer if the water contained *bouillon;* hence the author infers they are able to nourish themselves.

To keep the sperm alive long the amount of sea-water added must not exceed nine times the bulk of sperm. When the sperm and water formed an opaque white liquid the sperms lived seventy-two hours; but when the sperm was diluted with water till only slightly turbid the sperms died in three to five hours.

That the sea-water stimulates the sperm is inferred from the observation that even immature sperms became active when put into water.

The eggs of this sea-urchin are in best condition for fertilization during the first four hours after being discharged into the water, but there is little loss of vitality up to nine hours. In seventeen hours many develop abnormally, and many not at all. In twenty to twenty-four hours only one to two per cent develop, and no development was observed after twenty-eight hours. On the other hand, when the eggs were fertilized immediately after discharge into the water, polyspermy and irregular development were apt to take place.

[1] *Journ. Anat. Phys.*, vol. xxxiv, January, 1900.

When an adult was kept thirteen hours in the air there were no normal developments from the eggs as first shed, but when these eggs were kept four hours in water seventy-five per cent developed. The author interprets this as meaning that the eggs were in a "state of semi-asphyxia" and gradually recovered in the water.

The action of sperm upon moribund eggs is remarkable in that it hastens their disintegration, causing them to form blister-like elevations, to become vesiculated, and to exhibit a sort of pseudo-cleavage. When dead the eggs are not changed by sperm and keep their form for days.

E. A. A.

Animal Life.[1] — This text-book of zoölogy is outside the usual line, as might be expected in one of Appleton's "twentieth-century text-books," written by the president of Leland Stanford University. Like the *Study of Animal Life* of Arthur Thomson, it is not a laboratory manual but a book to be read for stimulus and instruction, not for training in observation and deduction.

It is a book on animal "ecology," emphasizing life as *adaptation*. In it structure and function go hand in hand, function leading the way.

The authors briefly consider the activities of the Protozoa, and the lowest Metazoa, then take up chapters upon the sex and reproduction of animals, function and structure, the life cycle, the primary conditions of animal life, the crowd of animals and the struggle for existence, adaptations, animal communities and social life, commensalism and symbiosis, parasitism and degeneration, protective resemblances and mimicry, the special senses, instinct and reason, homes and domestic habits, and the geographical distribution of animals.

Its simple elementary treatment, excellent illustrations, and the piquancy of new facts gathered from the Pacific shores make it a most attractive volume which should play a good part in awaking interest in zoölogy. Yet used as "a first book" and, it may be, as an only book, there is danger of catering to the desire to know what we now think of animals rather than to know animals themselves.

E. A. A.

The World of the Great Forest.[2] — This latest product of Du Chaillu's busy pen is an endeavor to present to young people a

[1] Jordan, D. S., and Kellogg, V. L. *Animal Life.* A First Book of Zoölogy. New York, Appleton, 1900. 311 pp., 180 figs.

[2] Du Chaillu, Paul. *The World of the Great Forest.* With over fifty illustrations by C. R. Knight and J. M. Gleeson. New York, Charles Scribner's Sons, 1900. 322 pp.

picture of animal life in the forests of equatorial Africa. The book is divided into short chapters, each devoted to a pair, or a community of animals, from the huge pachyderms to the smallest insects. The animals are made to discourse very naïvely to each other on the hardships and joys of their life, and to describe the special adaptations that fit them for it. There is no attempt at a connected story, or at any incidents which would not naturally result from the simple motives which influence the actions of animals, their care for their young, and their desire for food. The book is the story of the vicissitudes of wild life, the periods of plenty alternating with those of want, — a life where only activity or ingenuity or patience can hope to maintain itself. This is a refreshingly wholesome point of view in this age, when our views of animals are too much tinged by imaginative sentiment. The constant repetition of much the same story, however, makes the three hundred and odd pages rather difficult reading, especially as they are never lightened by a ray of humor. Native names for the animals are early introduced and then used exclusively, so that the memory must bear a constantly increasing burden. When the "nkengos" say that they are glad that they have found no traces of "nginas, nshiegos, mbouvés, and kooloo-kambas," we gain, despite the glossary, but a confused idea of the cause of their joy. The book will hardly arouse an interest in animals in children who do not already possess it, but on the other hand it will teach them nothing that is not true, unless it be an exaggerated idea of the range of an animal's thought. The book cannot fail to win a valuable place in a school or juvenile library, and will teach those who have an interest in animals many details of the life history of African animals in particular, and a very just conception of wild life as a whole. The illustrations are all good and some are excellent.

R. H.

Mooswa and Others of the Boundaries.[1] — The author of *Mooswa and Others of the Boundaries* says in his introduction: "Perhaps this story is too simple, too light, too prolific of natural history, too something or other — I don't know; I have but tried to tell the things that appeared very fascinating to me under the giant spruce and the white-barked poplars, with the dark-faced Indians and the open-handed white trappers sitting about a spirit-soothing camp-fire." The suspicion here intimated that he has perhaps not succeeded in

[1] Fraser, W. A. *Mooswa and Others of the Boundaries.* Illustrated by Arthur Heming. New York, Charles Scribner's Sons, 1900. 260 pp.

imparting the fascination to his readers seems to us justified. The story is certainly "light," but whether it is "too prolific of natural history" may be questioned.

The scene of the story is laid in the forests of the Athabasca, in which a lad of fourteen spends the winter in the charge of a half-breed trapper. The interest of the story lies in the successful efforts of the animals of the region to save their skins from the trapper, and later in the endeavors of Mooswa, a moose whom the boy once befriended, to save the boy from starvation.

If the book is an attempt to convey, in the form of a story, knowledge of the ways of animals, it is a failure, for whatever truth it may contain is obscured by a bewildering amount of romance. Thus when the fox is caught in a trap, the beaver gnaws off his foot, and the Canada Jay sews the skin over the stump with his beak. If the author has tried to make a good tale, after the pattern of the Jungle Books, he has failed through lack of the requisite literary skill. The story is presumably intended for boys, but even boys, if fed on Kipling and Seton-Thompson, would tire of the idle chatter which is put into the mouths of the principal interlocutors. The book is by no means bad; there are humorous situations, and even moments of interest, approaching excitement. A decade ago it might have proved acceptable, but the standard of excellence in such matters has been set too high, by the creators of Mowgli and Wab, for any but skillful artists to hope for success in the field. The illustrations are far superior to the text.

R. H.

Miller's Key to the Land Mammals of Eastern North America.[1]—Probably no recent contribution to the literature of North American mammalogy will be so gratefully and widely welcomed as Mr. Miller's brief synopsis of the land mammals of eastern North America. So great has been the increase in our knowledge of the subject during the last fifteen years, so radical the changes in nomenclature, so different the present methods of investigation, and so scattered the literature that has been the outcome of this renaissance, that only the few specialists engaged in the work could hope to keep in touch with the subject. The general student hence found himself hopelessly lost in intricate labyrinths in any attempt he might make to gain a clear conception of the results thus far reached, in even a limited

[1] Miller, Gerrit S. Key to the Land Mammals of Eastern North America, *Bulletin of the New York State Museum*, vol. viii (October, 1900), No. 38, pp. 59–160.

field. Mr. Miller's Key gives at once a bird's-eye view of the scene, and directs the inquirer where further information may be obtained.

The geographical scope of the work includes "the entire mammalian fauna of the Atlantic slope of North America north of the southern boundary of the upper austral zone," or the Atlantic slope from Hudson Bay to the southern boundary of what is commonly known as the "Carolinian Fauna." The Mississippi drainage area is thus wholly excluded. A brief introduction defines the life zones of the region and the plan of the Key, followed by a synopsis, giving a classified list of the higher groups, species and subspecies. Then comes the Key proper, supplying diagnoses of all the groups from class to subspecies, subfamilies and subgenera excepted. Under each species and subspecies are given "references to (1) the first publication of the specific or subspecific name, (2) first use of the binomial or trinomial combination, and (3) a recent monographic paper in which the form is described in detail. . . . The type locality is given in parenthesis after the first reference. The accented syllable of all technical names is marked by an accent; and the derivation of each name is placed in parenthesis at the end of the diagnosis." A paragraph, in larger type, follows the diagnosis, giving the distribution of the species or subspecies under consideration. The Key is thus intended to give the correct nomenclature for all the forms treated, with a clue to their identification, and a brief statement of their geographical ranges, generally indicated by a reference to the "life zone" they inhabit. This admirable brochure is thus what it claims to be, a "key" to the subject, and an aid to the acquisition of further information. That the work was greatly needed, has been well done, and will prove a "boon" to seekers of knowledge in this field, it is needless to further affirm.

The Key was originally planned to form part of Mr. Miller's recently published "Preliminary List of the Mammals of New York" (see *American Naturalist*, April, 1900, pp. 316–318), but "soon grew to the proportions of an independent paper," and was finally extended to include a larger area. The Key, we regret to see, repeats the few errors of nomenclature of the list, to one of which attention has already been called in this journal (*loc. cit.*, p. 318), namely, the highly questionable basis of the specific name "americanus" for the Virginia deer. Another case is the use of the specific name "hudsonica Desmarest" (1803) for the otter. As we have already shown (*Bull. Amer. Mus. Nat. Hist.*, Vol. X, 1898,

pp. 459, 460), canadensis Schreber (1778) is perfectly tenable for this species, for those who accept names based on plates, as does Mr. Miller in the case of the mink, *Putorius vison* (Schreber), which rests on the same basis as *Lutra canadensis* (Schreber) for the otter. Moreover, the name "canadensis" had been in almost universal use for this species till two years ago, when an unfortunate attempt was made to replace it by "hudsonica," of twenty-five years later origin.

Another case that may be mentioned is the use of the generic name "Rosmarus" for the walruses instead of the prior name "Odobenus." Rosmarus Scopoli dates from 1777; Odobenus Brisson from 1756, becoming perfectly tenable from Brisson's second edition of his *Règne Animal*, published in 1762, or fifteen years before the tenable date of Rosmarus. We can hardly believe Mr. Miller has given these points due consideration.

There are no really new innovations in the technical nomenclature, but a new subspecies of the common deer is described on p. 83, under the name *Odocoileus americanus borealis*. The number of species treated is 105, with thirty-three additional subspecies.

J. A. A.

Pectoral Girdle of Reptiles. — Professor Max Fürbringer's[1] long interrupted studies on the comparative anatomy of the pectoral girdles and their muscles and nerves in vertebrates have been continued in a fourth part devoted to these organs in the Amphisbænia and the reptiles. The first 150 pages are devoted to an extended account of the skeletal elements of the pectoral girdles, breastbone, and humerus, including these parts in the fossil as well as in the recent representatives of the groups under consideration. This is followed by an account of the nerves to the shoulder muscles, after which a very exhaustive description of the shoulder muscles themselves is given. A final discussion of over 150 pages deals in a comparative way with the facts brought forward in the descriptive part and concludes with remarks on the phylogenetic relationships of the groups of reptiles to one another, to the birds, and to the lower vertebrates as shown by the structure of the parts described. The illustrations, some seventy figures in all, are beautifully clear and exact, and with the text constitute a work of monumental proportions,

P.

[1] Fürbringer, M. Zur vergleichenden Anatomie des Brustschulterapparates und der Schulterumskiln, *Jena. Zeitschrift für Naturwissenschaft*, Bd. xxxiv (September, 1900), pp. 215–718, Taf. XIII–XVII.

The Neurone in Anatomy and Physiology. — The neurone theory of the structure of the nervous system as promulgated by Waldeyer in 1891 has been subjected to nearly ten years of rigorous criticism, and the outcome of this, so far as the present standing of the theory is concerned, has been well presented by Professor Verworn,[1] in his address before the Seventy-Second Meeting of the German Naturalists and Physicians. The fundamental postulate of the neurone theory, namely, that nerve fibres are processes from ganglion cells and that the so-called ganglion cell with these processes constitutes the real cellular unit of the nervous system, is clearly stated at the outset. The possibly closer union of these units than has heretofore been admitted, particularly by the adherents of the contact theory, is considered in the light of the recent work by Apáthy and by Bethe and pronounced still uncertain. The whole issue of this discussion is rightly shown to be of secondary importance so far as the stability of the neurone theory is concerned.

From the physiological side the author makes an excellent presentation of the question as to the significance of ganglion cells. The recent arguments of Bethe and of Steinach, to the effect that central nervous operations are possible without ganglion cells, are shown to be inconclusive, and many important observations made on animals subjected to nerve poisons are adduced to show that central nervous operations are dependent on ganglion cells for more than a supply of nutritive material. The essay concludes with the statement that the anatomical and physiological investigations of the last ten years have left the neurone theory on a firm basis and is unquestionably one of the best recent estimates of the present standing of that theory.

P.

Avian Helminths. — An important contribution on the frequence and distribution of the internal parasites of birds has recently been published by Wolffhügel.[2] In all 630 hosts belonging to 73 species of birds were examined. Most of them were native in the country immediately bordering on the southern Rhine, but a few came from the collection of the Basel Zoölogical Garden. In all 180 birds proved to be uninfected; the rest harbored of cestodes 35 species in 231 hosts, of trematodes 19 species in 124 hosts, of nematodes 26 species in 252 hosts, and of Acanthocephala 11 species in 41 hosts.

[1] Verworn, M. *Das Neuron in Anatomie und Physiologie.* Jena, G. Fischer, 1900. 54 pp.

[2] Wolffhügel, K. *Beitrag zur Kenntnis der Vogelhelminthen.* Dissertation. Freiburg, B. 1900. 204 pp., 7 double plates.

Different kinds of birds varied very greatly in number and type of parasites sheltered, and forms common in the one would be entirely absent or rare in the other. Full results of the examinations are given in a series of tables which show the number, condition, location, and name of the parasites collected and the date, locality, collector, and name of the host. The second half of the paper is devoted to an anatomical description and discussion of some of the less known cestodes found. The descriptions are full and contain many new points which are well illustrated on the plates. One new species, *Hymenolepis tetraonis*, was discovered in the quail, in which it is apparently very common. H. B. W.

Revision of the Ticks. — Of this work by Neumann,[1] a third part has just appeared. It covers the tribe of the Ixodæ, including the eyeless genera Ixodes, Hæmalastor, and Aponomma, and the genera Hyalomma and Amblyomma which possess eyes. Analytical keys for each genus, based on the characters of the male, of the female, and of the nymph, and full bibliographic references make the work a mine of information. Inasmuch as the ticks from the collection of the Bureau of Animal Industry were placed in the hands of the author for this revision, it has a peculiar value for American students; this usefulness is greatly enhanced by the full references given under geographical distribution to the individual states of the Union from which the specimens have been collected. With delicate courtesy the names of new species taken from labels written by the late George Marx are used and the species credited to that author; many of his drawings are also incorporated in the article, although for the text Professor Neumann is alone responsible. The most important change in the nomenclature of American forms is the suppression of *Ixodes unipunctata* Packard, the Lone Star Tick, as synonymous with *Amblyomma americanum* Koch. The illustrations of the revision are good, the text clear and concise, and the work is evidently carefully done, making it altogether the most important contribution in this group since the monograph of Koch. A fourth part to include additions, corrections, and general considerations of a taxonomic character to conclude the work will appear soon. H. B. W.

The Coccidæ of Brazil. — As recently as 1897 Dr. H. von Ihering catalogued the Coccidæ of Brazil, but he was able to enumerate

[1] Revision de la famille des ixodidés, *Mém. Soc. Zool. France*, tome xii (Paris, 1899), pp. 107–294, 63 figs.

only twenty-one species. Mr. Adolph Hempel has since that time been actively engaged in their study, and as a result he has published a work entitled "As Coccidas Brazileiras," in which he describes no less than 131 species as occurring in Brazil. This work, which was received by the present writer on Sept. 26, 1900, appears in Vol. IV of the *Revista do Museu Paulista*, and is, unfortunately, in Portuguese. By reason of its place of publication and the language in which it is written, it may escape the attention of some coccidologists, but it is in reality one of the most important contributions to the study ever produced.

The new genera described are Cryptokermes, Stigmacoccus, Apiococcus, Tectococcus, Tectopulvinaria, Pseudischnaspis, and Diaspidistis. Stigmacoccus, though placed in the Coccinæ, is doubtless a Monophlebine, and singularly enough, it appears to be identical with Perissopneumon, Newstead, described from India in *Entomologists' Monthly Magazine*, November, 1900. The simultaneous discovery on opposite sides of the world of this striking and distinct type is remarkable. Pseudischnaspis is an offshoot from Chrysomphalus, and will include, besides the Brazilian species, *P. longissimus* (Ckll.) and *P. bowreyi* (Ckll.), hitherto referred to Chrysomphalus.

T. D. A. COCKERELL.

Notes. — The development of the common tubularian, *Parypha crocea*, has been worked over by C. M. Allen (*Biol. Bull.*, Vol. I, p. 291). Each sporosac is an outgrowth of the body wall of the polyp, and since it shows evidence of four radial canals, it must be regarded as a much reduced medusoid. The genital cells, both male and female, are derived from the ectoderm of the medusoid. The egg grows by absorbing adjacent cells. Its nucleus is said to be absorbed at an early stage and is later re-formed from the scattered fragments. Segmentation is very irregular and is often outrun by the nuclear divisions. The ectoderm and entoderm are differentiated by delamination. The embryo escapes as an actinula with both basal and buccal tentacles.

The segmentation of that portion of the neural tube which forms the brain in teleosts has been studied by Charles Hill (*Zool. Jahrb.*, Bd. XIII). The region destined for the forebrain is represented by three segments, that for the midbrain by two. These segments early disappear and are replaced by secondary expansions which have been mistaken for segments. The segments of these two portions of the brain are serially homologous with those of the posterior

part which are six in number and persist to a much later stage in ontogeny. Of these the first gives rise to the cerebellum, and the remaining five to the medulla. The brain thus consists of eleven neural segments.

As a suggestion of what might be done, the work of T. B. Pieri (*Arch. Zool.*, Exp. III, p. xxix) is interesting. Having shaken the sperm of sea-urchins in a bottle of water for one-quarter of an hour, he found the sperms apparently dead. When passed through a filter the liquid, water and sperm, was added to sea-urchin eggs and these developed into many-celled stages. The author would fain see here the action of a soluble ferment which he would call ovulase; this truly would be "féconde en consequences biologiques et philosophiques." However, he sees clearly that the experiments fail in that the filtration did not remove the sperms and that some of the sperms may not have been killed.

The free-swimming copepods of the Woods Holl region have been described in the *United States Fish Commission Bulletin* for 1899 by Professor W. M. Wheeler. The paper contains accounts of thirty species, several of which are new, as well as excellent tables for the identification of these crustaceans.

The peripheral distribution of the cranial and first two spinal nerves of the salamander, *Spelerpes bilineatus*, has been worked out by Miss M. A. Bowers. The paper, which is published in Vol. XXXVI of the *Proceedings of the American Academy of Arts and Sciences*, is illustrated by four figures in which the nerve components are brought out by appropriate colors.

Special Bulletin No. 4 from the United States National Museum consists of a monograph of the American hydroids belonging to the family Plumularidæ by Professor C. C. Nutting. The memoir includes a general account of the group and descriptions of some 120 species, nearly half of which are new to science. It is illustrated by thirty-four plates, containing over 300 figures.

The peculiar trematode, *Macraspis elegans* Olsson, has been studied recently by Jägerskiöld (*Kgl. Vet.-Akad.*, pp. 197–214, Stockholm, 1899). Good illustrations give the form, which varies greatly as between old and young individuals. The entire structure, especially that of the reproductive system, shows such similarity with that of the digenetic trematodes that the author is not inclined to separate the Aspidobothridæ so widely from them as has been the custom hitherto.

A new genus of ectoparasitic trematode, *Aporocotyle simplex*, has been discovered by Odhner (*Centralb. Bakt. u. Par.*, 1. Abt., Bd. XXVII, p. 62) on the gills of Pleuronectes. It stands in sharp contrast with all forms of the group hitherto described, in that it lacks entirely the suckers and all other specialized apparatus for attachment so characteristic of the group.

The endoparasitic trematodes of Chelonia are treated by Braun in two articles (*Centralb. Bakt. u. Par.*, 1. Abt., Bd. XXV, p. 714, and Bd. XXVI, p. 627). A considerable number of species, both old and new, are carefully described. Among the latter is an American form, *Monostoma renicapitate*, which has not been noted since the original scanty description of Leidy.

The species of Filaria found in human blood are discussed by Von Linstow (*Zool. Anz.*, Bd. XXIII, p. 76). The characteristics of each supposed species are given in full, with citations from some rather inaccessible authorities. The distribution of each is also considered.

Mr. Willis S. Blatchley's *Twenty-fourth Report of the Geological Survey of Indiana* contains, besides important geological and mining matter, a number of valuable papers on the local natural history. E. B. Williamson contributes a descriptive catalogue of the Dragon-flies; R. E. Call, an illustrated catalogue of the Mollusca, and Stanley Coulter a catalogue of flowering plants and ferns. Mr. Blatchley continues his useful notes on the reptiles and batrachians of Vigo County.

BOTANY.

Two Recent Mushroom Books. — The last half decade has been notable for the number of new mushroom books and papers, and even more for the increase in fungus-eating in this country. Up to the time that the late Mr. Gibson turned his happy faculty of pen and pencil to the subject, most people had held a vague but fixed idea that none but the expert mycologist could turn mycophagist at large without the probability being great that his friends would ultimately record in sadness the final result of some last experimental eating of a species "supposed to be" wholesome, — only Morels, "the" Mushroom, and a few others grossly marked being safe for the layman's consumption. By his clear descriptions and exquisite

illustrations Mr. Gibson made possible the recognition of a few — but sufficient — common edible species, while the fact that nearly all of the fatal cases of toadstool poisoning are caused by *Amanita muscaria*, and *A. phalloides* and its closest relatives, led him to brand the genus Amanita so forcibly that few of us now care to eat any volva-bearing agaric, however wholesome and delicious experience may have shown it to be. The only really weak point in his *Our Edible Toadstools and Mushrooms* lies in the very emphasis of this most wholesome warning against all amanitas, which causes the minor caution against lurid Boletuses, the emetic Russulas, and other "suspected" species to be overlooked, — a caution reiterated emphatically in Professor Farlow's review of the book in the columns of *Garden and Forest.*

Mycological clubs and amateur mycophagists have wonderfully multiplied and thriven under the stimulus of this book, which, with its selection of a few unmistakable edible agarics and its branding as deadly of the Amanitas, provides a sufficiency of fungus food for ordinary culinary purposes, with a good mapping out of the safest lines of exploration for the venturesome who must go farther. So far as I know, no fatal or extremely serious cases of toadstool poisoning traced to species not of Amanita have occurred in this country in the last few years, except that a well-known phycologist, turned mycophagist, slipped in his determination of a Boletus which he thought he recognized from one of Mr. Palmer's plates, and, with his family, paid a severe, if not the extreme penalty for the error; and that one fatal mistake and several less serious ones have been made in considering *Agaricus* (*Lepiota*) *morgani*, an agaric rather common especially in the West, as fit for food, as its congeners appear to be.

The latest important contributions to mushroom literature are by Professor Atkinson [1] of Cornell University, a teacher of cryptogamic botany, and Captain McIlvaine,[2] who for the past twenty years has been well to the front among the fungus-eaters in this country. Both of these writers are evidently aiming at the same purpose,

[1] Atkinson, G. F. *Studies of American Fungi.* Mushrooms, Edible, Poisonous, etc. Ithaca, N. Y., Andrus & Church, 1900. vi + 275 pp., with 200 photographs by the author and colored plates by F. R. Rathbun.

[2] McIlvaine, C., and Macadam, R. K. *Toadstools, Mushrooms, Fungi, Edible and Poisonous.* One Thousand American Fungi: How to Select and Cook the Edible; How to Distinguish and Avoid the Poisonous. Indianapolis, The Bowen-Merrill Company, 1900. xxxvii + 704 pp., Pl. LXVII, and many illustrations in the text.

Professor Atkinson stating that he has tried to present the important characters which it is necessary to observe, in an interesting and intelligible way, and to illustrate these by life-size photographic reproductions of the larger fungi, the selection of species being made with a view to the representation of the more important genera, chiefly those containing edible species; while Captain McIlvaine, regretting the absence of any book giving the genus, names, and descriptions of the prominent American toadstools, the edibility of which has been tested or the poisonous qualities of which have been discovered, has attempted to give such information for every species known to be esculent in North America.

Both books are illustrated by colored plates and process reproductions from photographs, which, particularly in Captain McIlvaine's book, are supplemented by diagrammatic drawings. The illustration of pileate fungi is a subject about which opinions may and apparently do differ widely. Few colored plates, not even excluding those of the olden time, which were hand-tinted on a lithograph or engraving, represent the colors any too naturally, and it must be said that the illustrations in color in these two books, though often pleasing to the eye, do not materially affect the truthfulness of this statement. On the other hand, uncolored drawings fail to represent characters which, though imperfectly shown in an ordinary colored plate, may be sufficiently closely suggested in it to serve their purpose. The two books in hand contain a wealth of photographic illustration which in excellence is scarcely surpassed by Mr. Lloyd's well-known photogravure sheets of certain American fungi, and which may be taken as representing nearly or quite the best that can be done by process work; and yet, exquisite as some of this work is, and faithful as the photographic portrait must of necessity be, it is doubtful whether the technical characters which, no less than the gross characters, need to be brought out in illustrating the pileate fungi, are as well shown in the greater number of cases as they could be by an artist's skill, guided by the unimpeachable accuracy of the camera and controlled by the fresh dissection.

Both books are primarily intended for the fungus-eater, and yet their scope is very different, and in both cases extends further than that of Mr. Gibson's book already referred to. Professor Atkinson, while covering the genera pretty fully, devotes a great deal of space to comparatively few, but representative, species, poisonous or edible, while Captain McIlvaine, with nearly or quite equal fullness of treatment, attempts to account for everything. It is easier to

prepare a monographic treatment of an entire group, provided one have the material and the literature at hand, than to make and describe a selection of interesting things from that group, since in the former case, barring errors of omission, provided the work be well done, whatever is sought is sure to be found, while in the other case inevitable disappointment awaits the person hoping to learn about something which the author did not consider it desirable or expedient to include. Doubtless Professor Atkinson's book will so disappoint many people, and yet, for even the laboratory student of pileate fungi, it will prove of great value. On the other hand, Captain McIlvaine's book, lacking the critical touch of the expert mycologist, though it contain the names of plants sought, will probably lead to a certain amount of error; yet it too is a book which should be found on the departmental shelves of every American institution in which mycology is taught. For the novice in fungus-eating, both, though helpful, are likely to prove confusing, since the distinctions made between species in the larger book may not prove easy to make with the fresh plants, in many cases, while the number treated in the smaller book, though restricted, is sufficiently great to embarrass ordinary people by tempting them into difficult paths; and no book of a scope greater than that of Mr. Gibson's, in which only thirty edible species are included, is likely to supplant it for the amateur American mycophagist. The present books, like Gibson's, contain numerous recipes for preparing and cooking edible species, and, for the most part, these promise easily made and palatable luxuries where fungi can be obtained in the fresh state.

Perhaps, in view of the uncertainties attending the use of fungi as food, it may be as well to state that in addition to the avoidance of amanitas, even including the wholesome ones for the sake of greater safety, all species unpleasant to the taste or acrid, all Boletuses, and all specimens which show the slightest trace of discoloration or which have been allowed to become in the least stale, should be left to the person who proposes to derive sufficient pleasure from dangerous experimentation to justify in his own mind the tampering with unnecessary and sometimes great risks. Professor Atkinson, in speaking of the unwholesome species, quotes from chemists in a way to show that in addition to muscarine, the deadly alkaloid of *Amanita muscaria*, and phallin, the more deadly toxalbumin of *Amanita phalloides* and *A. verna*, choline, an alkaloid which in decomposition gives rise to muscarine or a related alkaloid more deadly than itself, and helvellic acid, likewise a most energetic

poison, have been isolated from a considerable number of species regarded ordinarily as dangerous only in a minor way or merely suspicious; and there seems little reason to doubt that much of the ambiguity attending fungi of this class comes from the conversion, in their incipient decay, of a minor and perhaps scanty poisonous substance into a much more dangerous one, so that personal idiosyncrasy or differences between individuals in strength of heart action seem capable of accounting for the divergence of opinion as to the edibility of a number of the dangerous species, like Boletuses, *Gyromitra esculenta*, certain Russulas, *Lepiota morgani*, and, indeed, the *Amanita muscaria* itself. T.

North-American Pteridophytes. — A sixth edition of Professor Underwood's handbook of the ferns and fern allies occurring north of Mexico,[1] which appears to have been carefully revised, has recently appeared and is likely to meet with ready sale. In it are incorporated records of the occurrence in one flora of several species not before recorded for it, and descriptions of several species regarded as new to science. The author's recent comprehensive investigations of the priority status of generic names in the ferns have been consistently followed up in this book by the rehabilitation of the well-known species of Cystopteris in the genus Filix, and of what has been known as *Blechnum* (or *Lomaria*) *Spicant* in the genus Struthiopteris, while Aspidium is now replaced by Dryopteris, Polystichum, Phanerophlebia, and Tectaria. T.

Notes. — An interesting note by Professor Kellerman, on an Ohio station for *Cissus ampelopsis* or *Ampelopsis cordata*, with illustrations, appears in the first number of a new journal, *The O. S. U. Naturalist*, published by the biological club of the Ohio State University, which also contains a list of additions to the Ohio flora, notes on collecting and preserving microscopical plants, and a paper by Kellerman on a foliicolous form of *Ustilago reiliana*, which species is believed to possess the characters of Cintractia rather than of Ustilago proper.

Viola alabamensis, a new purple-flowered acaulescent species, is described by Pollard in a recent issue of *Proceedings of the Biological Society of Washington.*

A revision of the Cactaceæ of Paraguay, by Schumann, is being published in current numbers of the *Monatsschrift für Kakteenkunde.*

[1] Underwood, L. M. *Our Native Ferns and their Allies, with Synoptical Descriptions of the American Pteridophytes North of Mexico.* New York, Henry Holt & Co., 1900. x + 158 pp., 35 ff., and frontispiece plate. Price, $1.00.

G. P. Burns publishes an illustrated anatomical study of the Stylidiaceæ in *Flora* for October.

The purple cone-flowers, *Echinacea purpurea* and *E. angustifolia*, have been hybridized for cultural purposes, as appears from a note, with illustrations, by Köhler, in *Die Gartenwelt* for October 20.

Curtis's Botanical Magazine for November contains illustrations of *Erigeron leiomerus* and *Cypripedium guttatum*, of the North-American flora.

A revision of the species of Platanus by Usteri appears in No. 20 of the *Mémoires de l'Herbier Boissier.*

A short popular article on *Monstera deliciosa*, with photographic illustrations, by Theodosia B. Shepherd, is contained in *The Land of Sunshine* for September–October.

A review of the Rocky Mountain Melanthaceæ by Rydberg appears in the *Bulletin of the Torrey Botanical Club* for October. Several species, and one genus, Stenanthella, split off from Stenanthium, are described as new.

K. M. Wiegand presents a revision of the tenuis group of Juncus, in the *Bulletin of the Torrey Botanical Club* for October. Thirteen species are recognized.

A well-illustrated "Short Account of the Big Trees of California" constitutes *Bulletin No. 28* of the Division of Forestry of the United States Department of Agriculture.

Keys to species of Abies and Picea based on leaf anatomy are given in a paper by H. B. Dorner, reprinted from the *Proceedings of the Indiana Academy of Science* for 1899.

The distribution of Chilian Coniferæ forms the subject of a paper by Karl Reiche in the current volume of the *Verhandlungen des deutschen wissenschaftlichen Vereins* of Santiago. Six genera, Podocarpus, Dacrydium, Saxegothea, Araucaria, Fitzroya, and Libocedrus, are considered.

The variations in *Lycopodium clavatum*, and their bearing on phylogeny, are discussed in a paper illustrated with three plates, by R. A. Robertson, in Part IV of the current volume of *Transactions and Proceedings of the Botanical Society of Edinburgh.*

The second fascicle of de Wildeman and Durand's "Contributions à la flore du Congo," published as a part of the *Annales du Musée du Congo*, of Brussels, has recently been completed by the issuance of a

second part, and contains descriptions of a considerable number of new species.

Professor Ascherson contributes a synopsis of the higher vegetation of Helgoland to Vol. IV, N.F., of the *Wissenschaftliche Meeresuntersuchungen* of the Commission for the Scientific Investigation of the German Sea.

Part I of the third volume of Boerlage's *Handleiding tot de kennis der flora van nederlandsch Indie*, comprising the orders Nyctaginaceæ to Casuarinaceæ, has recently appeared.

A series of contributions to the knowledge of the trees of Java, by Koorders and Valeton, is appearing in current numbers of the *Mededeelingen uit 's Lands Plantentuin*, of Buitenzorg.

A paper on "Some Plants of West Virginia," by E. L. Morris, is published in the *Proceedings of the Biological Society of Washington*, under date of October 31.

A number of papers on the plant geography of North America, presented at the New York meeting of the American Association for the Advancement of Science, are published in abstract in recent numbers of *Science*.

A delightfully simple elementary statement of "How Plants Live Together," by Bailey, constitutes *Teacher's Leaflet*, No. 19, of the Cornell University Experiment Station.

An ecological comparison of the arctic and antarctic floras, by Delpino, is reprinted from the publications of the *R. accademia delle scienze dell istituto di Bologna* for 1900.

The structural and superficial modifications induced in a number of succulents, when grown with a liberal supply of moisture, are considered by Brenner in an illustrated paper in *Flora* for October.

Die Gartenwelt for October 27 contains an interesting statement by M. Correvon of the successful manner in which he cultivates Alpine plants in the crevices of a wall in the suburbs of Geneva, and is illustrated by several half-tones, — among them a superb portrait of *Saxifraga longifolia*.

Bulletin 46 of the Agricultural Experiment Station of the University of Nevada, which is No. 2 of the nature-study bulletins of that institution, deals with the flowers and fruits of common trees and shrubs. *Bulletin 47* of the same series considers clover seeds and their impurities. Both are well illustrated.

The harvesting and preparation of balsam of Peru from *Myroxylon Pereirae* are described by Preuss in *Der Tropenpflanzer* for November with process illustrations.

Further notes on the plants known as Peyote and Ololiuhqui, by Dr. Urbina, are contained in recent numbers of the *Anales del Museo nacional de México.*

The botanical origin of coca leaves is considered quite fully by Rusby in *The Druggist's Circular* for November.

Two papers on marl, of botanical interest, are published in No. 6 of the current volume of the *Journal of Geology* by Professor C. A. Davis.

Dr. Kuckuck, in Bd. IV, N.F., of the *Wissenschaftliche Meeresuntersuchungen* of the Commission for the scientific investigation of the German Sea, describes his method of cultivating algæ in the open seas.

A voluminous account of the older Mesozoic flora of the United States, by Professor Lester F. Ward, is separately published from Vol. XX of the *Annual Report of the United States Geological Survey.*

An elaboration of the fossil cycads of the Yale museum, by Professor Ward, is reprinted from the *American Journal of Science.*

A biographic sketch of Torrey, and an account of the work of the Torrey Botanical Club, appear in the October *Bulletin* of that organization.

A portrait of Ernest Roze is published in No. 7 of the current volume of the *Bulletin de la société botanique de France.*

PALEOBOTANY.

A New Book on Fossil Plants.[1] — Dr. Scott's important contributions to our knowledge of fossil plants are too well known to students of palæobotany to need any introduction. The present work is a very satisfactory summary of much of his former work, and the substance of it was first presented in the form of a series of lectures delivered at University College, London, in 1896. The lectures, however, have been entirely recast and brought up to date.

[1] Scott, D. H. *Studies in Fossil Botany.* London, Adam and Charles Black, 1900. xiii + 533 pp., 8vo, 151 figs.

The plants dealt with are, for the most part, the vascular Palæozoic plants, — Pteridophytes and Gymnosperms, — but some space is also given to the Mesozoic types.

The first chapter is partly devoted to an exposition of the aims of palæobotany and explains the different forms in which fossil plants have been preserved; the latter part of the first chapter and the two following are devoted to the Equisetales.

The earliest forms of Equisetales (Archæocalamites) occur in the upper Devonian. These oldest types were in many respects allied to the sole living genus, Equisetum. From this stock arose the much more specialized Calamites of the Carboniferous, which showed a secondary growth of the vascular bundles and more specialized fructifications. The peculiar fossils described under the name "Annularia" are supposed to be the smaller leafy twigs of Calamites. The structure of the latter is often preserved most beautifully and shows great similarity to that of Equisetum, with which the sporangia also have much in common. The discovery of heterospory in certain species is an interesting point, but it was apparently much less marked than among the Lycopods and Ferns. Dr. Scott is very positive in maintaining the strictly pteridophytic nature of all the Calamarieæ. No Calamites are found above the Permian, the Mesozoic Equisetales being for the most part closely allied to Equisetum.

Chapter IV deals with the Sphenophyllales, which Dr. Scott considers are entitled to rank as a fourth class of the Pteridophytes, having certain affinities with both the Lycopods and Equisetales. Of existing genera, Psilotum approaches Sphenophyllum in the character of the vascular bundles, but as practically nothing is known of the fossil Psilotaceæ, it is questionable how close the relationship really is.

The very remarkable fructification known as Cheirostrobus, which apparently combines calamarian and lycopodiaceous characters, is considered by Dr. Scott to belong to the Sphenophyllales and to confirm his view that "the Sphenophyllales were the highly modified representative of an ancient stock from which both Lycopods and Horsetails have diverged."

Chapters V–VII deal at length with the very abundant remains of Lycopodiales. As was the case with the Equisetales, the group culminated in the Palæozoic era, and in the later formations only the smaller and less specialized types are encountered. Heterospory, which still occurs in Selaginella, was very pronounced, and in the case of certain forms closely resembling typical Lepidostrobus,

seeds were actually developed. In spite of this, Dr. Scott is not inclined to admit that there is any connection between the arborescent Palæozoic Lycopods and the modern Conifers, although this is suggested by the similarity in habit of the two classes. He concludes that there is no satisfactory proof that the early Lycopods gave rise to any group of the higher plants — a conclusion with which all botanists will not agree.

The Ferns are the subject of two chapters, in which the different types are clearly treated. Abundant remains of Ferns, often most beautifully preserved, occur in all the formations from the Devonian onward. Unlike the other three phyla of Pteridophytes, the Ferns have held their own, and at present constitute a very important element of the vegetation of many regions, especially in the mountains of the tropics.

The fructifications are in many cases well preserved, and it is clear that the earlier Ferns were mostly types allied to the existing Marattiaceæ, which are thus shown to be a very old type, — a conclusion reached independently by the writer some years ago, from a study of the living forms. The fossil Marattiaceæ, however, showed far greater diversity than the few existing genera. The other existing group of Eusporangiatæ — the Ophioglossiæ, — which in certain respects seems to present very primitive characters, is very unsatisfactorily known in a fossil state, perhaps due to the very slight development of firm tissues in most of them.

The occurrence of leptosporangiate Ferns in the Palæozoic rocks is rare, and their affinities doubtful. A small number of types, perhaps allied to modern Gleicheniaceæ and Osmundaceæ, have been discovered, but it is not until the Mesozoic is reached that any considerable number of these are encountered. Last of all to appear are the Polypodiaceæ, preëminently the modern fern type.

Among the most interesting of the Mesozoic Ferns were the Matoninæ, now represented by the single genus Matonia of the Malayan region. This is a synthetic type, combining characters of the Cyatheaceæ and Gleicheniaceæ.

One of the most important results of recent work with the Palæozoic fossils is the discovery of a group of plants intermediate between the true Ferns and the Cycads. These Cycadofilices have been extensively studied by Scott and Seward in England, as well as by several continental workers. Among the best known genera are Lyginodendron, Heterangium, and Megaloxylon. Many of these forms which are formed from the lower Carboniferous and the Permian,

have been described as Ferns, the best known being the genera Neuropteris and Alethopteris.

The earliest of all true seed-bearing plants were undoubtedly the remarkable group, the Cordaiteæ, as to whose affinities there has been much discussion. Their remains occur abundantly from the Devonian through the Carboniferous. They present certain coniferous features, especially in the character of the secondary wood, while, on the other hand, their structure recalls the Cycads, which they resemble in the structure of the leaves. Unlike most fossil plants, the flowers and fruits have been preserved with extraordinary perfection, even to the pollen grains which are found within the pollen chamber, much as in the case of living Cycads. Most extraordinary of all, so perfectly are the pollen grains and ovules preserved, that the antheridia and archegonia are still recognizable!

Whether the Cordaiteæ really represent a type intermediate between Cycads and Conifers, may perhaps be questioned, but they certainly are one of the most interesting of all the groups of fossil plants.

The Cycads, although occurring sparingly in the later Palæozoic formations, are especially characteristic of the Mesozoic, where, as is well known, they formed one of the principal plant types. It is evident that the Mesozoic cycadean forms were much more varied than the existing genera, which show comparatively little variety of structure.

While some of the fossil forms approach closely their living representatives, both in this character of the vegetative and reproductive parts, others are extremely different, this being especially true of the Bennettiteæ. These combined typical cycadean vegetative characters with fructifications of a very different kind, and not readily comparable to that of the true Cycads. The seeds, which have been very perfectly preserved, show a large dicotyledonous embryo, nearly filling its cavity. These remarkable fossils are especially abundant in our own Potomac formation, and from Jurassic and Cretaceous formations of the Black Hills, from which Professor Lester Ward has described many new species.

Of the true Cycadaceæ, Cycas probably goes back at least to the Lias.

The Coniferæ are but briefly treated. The earliest typical Conifers seem to have been allied to the Taxodieæ, to which the fossil genus Voltzia of the Upper Permian and Triassic seems to be allied. The Permian genus Walchia, which has been supposed to be allied to the

Araucarieæ, is only known from vegetative remains, the fructification being quite unknown. Unmistakable Araucarieæ are not known anterior to the Jurassic. The Abietineæ are probably somewhat more recent, but Cupressineæ are found in the Jurassic. The Taxineæ (exclusive of the much more ancient Ginkgo) are first met with in the Cretaceous.

The extraordinary genus Ginkgo, which with the Cycads represents the oldest existing type of seed-bearing plants, and is now represented by the solitary species, *G. biloba*, is recognized by Dr. Scott as the representative of a distinct order, Gingkoaceæ, which is represented by numerous forms in the later Palæozoic and earlier Mesozoic formations. Dr. Scott agrees with Seward in assuming a somewhat near relationship between the Gingkoaceæ and the Cordaiteæ.

The concluding chapter is occupied with a summary of the general conclusions presented in the preceding chapters. We can hardly agree with the conclusion that the great antiquity of the Pteridophytes, and the absence of the remains of Bryophytes in the Palæozoic formations, is a sound argument for the entire independence of the great divisions of Archegoniates. There certainly is no evidence of any other forms from which they could possibly have sprung, while the evidence of comparative morphology is overwhelmingly in favor of a common origin for all Archegoniates. The questions of their interrelationships are by no means so evident.

The book is handsomely printed, and the illustrations are well executed and very helpful in elucidating the text. We can heartily recommend the book to all botanists interested in the fascinating study of plant pedigrees.

D. H. C.

RECORD OF GIFTS, APPOINTMENTS, RETIREMENTS, AND DEATHS FOR THE YEAR 1900.

Educational Gifts for 1900. — Below we have summarized the gifts to colleges, institutes, and libraries which have come to notice during the eleven months of 1900, ending November 30. In its compilation we acknowledge especial indebtedness to *Science*. Scattered here and there the items have little significance, but gathered in this form they are ample evidence of the generosity of the American people.

Amherst College, $10,000, by the will of Edward N. Gibbs.

Barnard College, New York, $100,000.

Bates College, $20,000, for a library building, from Joseph A. Coran.

Beloit College, a conditional gift of $200,000, from one of its trustees.

Berea College, $50,000, from Dr. D. K. Pearson ; $150,000, by subscription.

Blackstone Library of Branford, Conn., $100,000, by the will of Timothy T. Blackstone.

Boston University, $50,000, by the will of O. H. Durrell.

Bowdoin College, $150,000, from Gen. Thomas H. Hubbard, for a library building.

Brooklyn Institute of Arts and Sciences, $15,000, by the will of Joseph C. Hoagland.

Brown University, $1,120,000, by subscription ; $250,000, from John D. Rockefeller ; $3500, by the will of Charles H. Smith ; a conditional gift of from $8000 to $30,000, by the will of the late A. D. McLellan ; $25,000, by the wills of each, John Nicholas Brown and Harold Brown.

Carleton College, $50,000 from Dr. D. K. Pearson.

Carnegie Institute, Pittsburg, Pa., funds for its enlargement from Andrew Carnegie, not to exceed $3,000,000.

Catholic University of America, $20,000, by the will of Mrs. Rebecca Reyburn ; $50,000, from Michael Cudahy.

Chicago Art Institute, $50,000, by the will of the late Sidney A. Kent.

Clark University, an indeterminate amount, by the will of the founder, Jonas Clark.

College of Physicians and Surgeons of Chicago, $25,000, from Dr. W. E. Quinn, for its library ; and $25,000, from Dr. D. A. K. Steele, for the pathological laboratory.

College of Physicians of Philadelphia, $5000, by the will of Dr. J. M. Da Costa.

Colorado College, $50,000, from Dr. A. K. Pearson.

Columbia University, $10,000, for books, from an anonymous donor; $100,000, by the will of the late Dorman B. Eaton, for a professorship of municipal science and administration; $100,000, from John D. Rockefeller, to endow the chair of psychology.

Cooper Union, New York, residuary legatee of the late John Halstead, the amount approximating $250,000; $300,000, from Andrew Carnegie; $200,000, from Abram S. Hewitt and Edward Cooper.

Cornell University, $80,000, anonymously, for a building for anatomy and physiology.

Covington, Ky., $40,000, from Andrew Carnegie, for a public library.

Danielson, Conn., $15,000, for a public library, by the will of Edwin H. Bugbee.

James Milliken gives in two gifts $716,000, for an industrial school in Decatur, Ill. Citizens have given $100,000 to the school, and $100,000 more is promised.

Earlham College, $25,000, from Frances T. White.

East Orange, N. J., $50,000, from Andrew Carnegie, for a public library.

Emporia College, $50,000, from Andrew Carnegie, for a library building.

Essex Institute, $10,000, from the estate of the late Walter Dixon.

Fairmount College, $50,000, from Dr. D. K. Pearson.

Fargo College, $50,000, from Dr. D. K. Pearson.

Hackensack, N. J., public library, land and a building to cost from $30,000 to $40,000, from William M. Johnson.

Hampden Institute, $100,000, by the will of Collis P. Huntington.

Harvard University, $100,000, by the will of the late Dorman B. Eaton, for the chair of science of government: $100,000, by the will of Mrs. Caroline Brewer Croft, for researches into the cause and cure of cancer; $2000, by the will of Barthold Schlesinger.

Haverford College, $40,000, by an alumni subscription for a gymnasium.

Kenyon College, $10,000, from Mr. Samuel Mather of Cleveland: $15,000, from Mr. J. P. Stevens, for a library fund: $5000, by the will of John Sherman.

Lafayette College, $45,000, by the will of Joseph E. Smaltz.

Lehigh University, $300,000, by the will of Frank Williams.

McGill University, $200,000, from Sir William C. MacDonald.

McKenzie College, $75,000, from Dr. D. K. Pearson.

Marinette, Wis., $50,000, from Isaac Stephenson, for a public library building.

Massachusetts Institute of Technology, $2000, by the will of Barthold Schlesinger.

Mechanics Institute of Rochester, N. Y., $200,000, from George Eastman.

Middlebury College, $50,000, from Ezra Warner, for a science building.

Mt. Holyoke College, $200,000, from Dr. A. K. Pearson.

New York Botanical Garden, $20,000, and one-twelfth of the residual estate of Judge Charles P. Daly.

New York University, $100,000, from Miss Helen Gould, for the erection of a "Hall of Fame for Great Americans"; $2500, from Professor and Mrs. E. R. Shaw, for a scholarship; $20,000, by the will of the late Robert Schell.

Oberlin College, $60,000, from Louis H. Severance, for a chemical laboratory; $50,000, from Dr. and Mrs. Lucius C. Warner, for a men's gymnasium; $75,000, by the will of Mrs. Caroline E. Haskell; $40,000, by the will of William Osborne; $5000, by the will of John Sherman.

Ohio Wesleyan University, $10,000, from Mrs. Elizabeth Mebarry; $35,000, by the will of Mrs. Eliza Chrisman.

Onarga College, $20,000, from Dr. A. K. Pearson.

Peabody Academy of Science at Salem, $26,000, towards an addition to its building.

Philadelphia, a building valued at $1,000,000. to the city, by P. A. B. Widener, for a free library and art gallery.

Philadelphia Academy of Natural Sciences, one-sixth of the estate of the late Charles E. Smith, estimated at $500,000.

Andrew Carnegie proposes to give buildings and an endowment of $1,000,000 for a polytechnic school in Pittsburg.

Princeton University, $45,000, by the will of Joseph E. Smaltz; $40,000, by the will of Dr. John S. Sayre, a portion to be used for fellowships in applied electricity and applied chemistry.

Radcliffe College, $2,000, by the will of Barthold Schlesinger.

Ripon College, $15,000, from O. H. Ingham, towards the school of science building.

Rush Medical College, $50,000, from Dr. Nicholas Senn.

Rutgers College, $10,000, by the will of the late Robert Schell.

Public Library, St. Albans, Vt., $10,000, by the will of Gov. J. G. Smith.

St. Lawrence University, $24,000, from a friend.

Salem Public Library, $10,000, by the will of the late Walter Dixon.

Spellman Seminary, $180,000, from John D. Rockefeller.

Syracuse University, $25,000, by the will of the late Erastus F. Holden.

Teacher's College of New York, $25,000, by the will of Miss Eliza T. Bryson, for a scholarship.

Tufts College, $45,000, by the will of Walter Dixon, also a third of the residuary estate.

Tulane University, $50,000, from Mrs. Caroline Tilton, for library purposes.

Union College, $10,000, from members of the Mather family.

University of California, $10,000, for books, $100,000 additional, subject to an annuity, and $150,000 in real estate, from Mrs. Jane K. Sather.

University of Chicago, $125,000, from A. C. Bartlett; $50,000, by will of the late Sidney A. Kent.

University of Pennsylvania, $250,000, from the estate of H. H. Houston; $50,000, for dormitories, the residue unrestricted; $5000, by the will

of Dr. J. M. Da Costa ; $250,000, from Mrs. Thomas McKean, for the law school building.

University of the South, $50,000, from George W. Quintard, of New York.

University of Topeka (proposed), about $250,000, by the will of Mrs. Eliza Chrisman.

Vanderbilt University, $250,000, by the will of the late Mary J. Furman.

Washington University, property yielding from $120,000 to $130,000 a year, from Samuel Cupples and Robert S. Brookings.

Washington and Lee University, $3000, by the will of Mrs. Juliet S. Bushford, for a scholarship.

Wellesley College, about $100,000, by the will of Captain George S. Towle ; $109,000, by subscription ; $100,000, from John D. Rockefeller.

Yale University, $1000, from Professor G. J. Brush ; $2500, from an anonymous donor ; $5000, from Mrs. Isaac H. Bradley, for lectures ; $700, by the will of Dr. James Campbell, for the senior prize ; $1000, from Mrs. H. F. English, for prize fund in art school ; $1000, from ex-President Dwight, for the art school ; $30,000, from W. E. Dodge. It is difficult to say how much of the bicentennial fund, amounting to over $1,000,000, is to be counted as the gifts of the year 1900.

Yankton College, $50,000, from Dr. D. K. Pearson.

York, Pa., $50,000, from Andrew Carnegie, for a public library.

APPOINTMENTS.

Dr. D. Anisito, professor of botany and zoölogy in the medical school at Asuncion, Paraguay. — Dr. George H. Ashley, professor of natural history in the College of Charleston, S. C. — Charles E. Banker, assistant in normal histology, Columbia University. — W. Bergt, professor extraordinary of geology in the Breslau Technical School. — Dr. R. H. Chittenden, professor of physiology in the medical school of Yale University. — Dr. E. B. Copeland, professor of botany in the University of West Virginia. — Dr. A. S. Eakle, instructor in petrology in the University of California. — Dr. Paul Eisler, professor extraordinary of anatomy at the University of Halle. — Dr. E. Ficalbi of Messina, director of the zoölogical collections of the University of Padua. — Carlton P. Flint, assistant in anatomy in Columbia University. — William E. Ford, instructor in mineralogy in Yale University. — Dr. B. T. Galloway, custodian of the grounds of the United States Department of Agriculture. — Dr. Gasparini, professor of anatomy in the medical school at Asuncion, Paraguay. — L. C. Glen, professor of geology at Vanderbilt University, Nashville, Tenn. — Dr. A. W. Grabau, lecturer in geology in Tufts College. — Dr. Lawrence E. Griffin, instructor in zoölogy in the Western Reserve University. — Dr. Joseph B. Grzybowski, docent for paleontology in the University of Cracow. — Dr. G. Gürich, professor of geology and mineralogy in the University at Breslau. — Dr. R. Hesse,

professor extraordinary of zoölogy in the University at Tübingen. — Dr. T. C. Hopkins, professor of geology in Syracuse University. — Dr. F. H. Howard, instructor in physiology in Williams College. — Dr. F. Insfran, professor of histology in the medical school at Asuncion, Paraguay. — Dr. S. Kästner, professor extraordinary of anatomy in the University at Leipzig. — Cyrus A. King, instructor in botany in Indiana University. — Dr. L. Kolderup-Rosenvinge, docent for botany in the Kopenhagen Technical School. — Dr. Kolkwitz, docent for botany in the agricultural school at Berlin. — Professor A. Kossel of Marburg, professor of physiology at Heidelberg. — Professor K. Lampert, curator of the royal natural history collections at Stuttgart. — Dr. August Leppla, state geologist of Prussia. — Dr. A. Loewy, professor of physiology in the University of Berlin. — Dr. C. E. Lord, assistant in mineralogy and petrography in Harvard University. — Alexander Macphail, professor of anatomy in St. Mungo's College, Glasgow. — Maud Metcalf, assistant in botany in Wellesley College. — Dr. W. Nagel, professor extraordinary of physiology in the university at Freiburg. — Professor Henry F. Osborn, vertebrate paleontologist of the United States Geological Survey. — Dr. Oustalet, professor of zoölogy in charge of mammals and birds in the Musée d'Histoire Naturelle at Paris. — Percy J. Parrot, entomologist to the experiment station at Geneva, N. Y. — Dr. P. Peña, professor of physiology in the medical school at Asuncion, Paraguay. — Dr. N. von Raceborski, professor of botany in the agricultural school at Dublany, Galicia. — Professor A. Richter, director of the botanical institute and gardens of the university at Klausenburg. — Dr. F. Römer of Breslau, curator of the Senckenberg Museum at Frankfurt a. M. — Dr. G. E. Rogers, demonstrator in anatomy in the University of Cambridge. — Professor la Valette St. George, rector of the university at Bonn. — Dr. Sauer, professor of mineralogy in the Stuttgart Polytechnic School. — Dr. Alfred Schaper, professor extraordinarius of anatomy in the university at Breslau. — Dr. F. Schulz, professor extraordinary of physiology in the university at Jena. — Dr. M. Schwarzmann, docent for mineralogy in the university at Giessen. — Lena Edwards Shetley, assistant in zoölogy in Wellesley College. — D. N. Shoemaker, assistant in zoölogy in the Johns Hopkins University. — Dr. G. Elliot Smith, professor of anatomy in the medical school at Cairo, Egypt. — Dr. R. Wilson Smith, professor of botany in McMaster University, Toronto. — Dr. O. Zur Strassen, professor extraordinary of zoölogy in the university at Leipzig. — Dr. Tchermack, assistant in physiology in the university at Halle. — Dr. Georg Thilenius, professor extraordinarius of anthropology in the university at Breslau. — Dr. Victor Uhlig of Prag, professor of paleontology in the university at Vienna. — Dr. Ernst Weinschenk, professor extraordinarius of petrography in the University of Munich. — Mr. A. F. Woods, chief of the Division of Vegetable Physiology and Pathology in the United States Department of Agriculture. — Dr. Oskar Zeise, district geologist in the Geological Institute at Berlin.

RETIRED.

Professor T. G. Bonney, from the chair of geology in University College, London, after a service of thirty years. — T. Nelson Dale, instructor in geology in Williams College. — Dr. H. von Eck, professor of geology in the Stuttgart Technical School. — Carl Gegenbaur, professor of anatomy in the university at Heidelberg, at the age of 74. — Dr. B. Klunzinger, professor of zoölogy in the Stuttgart Technical School. — Dr. E. Schmidt, professor of anthropology and ethnology in the university at Leipzig.

DEATHS.

Sir Henry Wentworth Dyke Acklund, the well-known anatomist and physician, October 16, aged 85. — Dr. John Anderson, zoölogist and former curator of the Indian Museum at Calcutta, at Buxton, England, aged 66. — Paul Blanchet, explorer, of yellow fever, in Senegal. — Dr. G. Clautrian, assistant in the botanical institute of the University of Brussels, at Davos, Switzerland, May 23, aged 37. — Dr. A. B. Frank, professor of botany in the Agricultural School in Berlin, September 27, aged 61. — Dr. S. Gheorgieff, professor of botany in Sofia, Bulgaria, May 22. — I. Ingenitzky, entomologist, at Nowovossiisk, Russia, May 20. — Abbé A. B. Langlois, botanical collector, at St. Martinsville, La., August 1. — Dr. Joseph Mik, student of Diptera, at Vienna, October 13, aged 62. — Victor Lopez Sevane, ornithologist and entomologist, at Coruña, Spain, July 14. — General Sir R. Murdoch Smith, director of the Museum of Science and Art, at Edinborough, June 3. — Miss Margaret Stokes, an Irish archæologist. — Dr. A. von Strombeck, geologist, in Braunschweig, July 25, aged 91. — Professor G. H. F. Ulrich, geologist and director of the School of Mines at Otago, New Zealand, in May, as the result of an accident while collecting.

CORRESPONDENCE.

To the Editor of the American Naturalist:

SIR, — Under the name of *Xenichthys xenurus*, and afterward that of *Kuhlia xenura*, a fish in the U. S. National Museum, No. 4356, which was found in a bottle labeled "San Salvador," was described by Jordan and Gilbert. I have since had serious doubts whether this specimen really came from San Salvador and have thought that it was derived from some Asiatic source. Mr. Barton A. Bean has compared it at my request with the description of *Kuhlia malo* from the Hawaiian Islands. According to Mr. Bean it agrees perfectly with this species, except that the depth of body is $3\frac{1}{2}$ times in length, while in the adult of the other it is from $2\frac{2}{3}$ to 3. This difference is doubtless due entirely to difference in age. The pectoral fin has the measurement recorded by Boulenger for *Kuhlia malo*, and the black on the posterior margin of the caudal is very apparent. *Kuhlia xenura* should therefore be stricken from the list of American fishes. It is probable that the type came from Honolulu. where *Kuhlia malo* is very abundant.

D. S. J.

STANFORD UNIVERSITY, CALIFORNIA,
November 15, 1900.

PUBLICATIONS RECEIVED.

BAILEY, L. H. Botany. An Elementary Text for Schools. New York, Macmillan, 1900. xiv, 355 pp., 8vo, 500 figs. $1.10. — DU CHAILLU, PAUL. The World of the Great Forest. How Animals, Birds, Reptiles, Insects, talk, think, work, and live. Illustrations by C. R. Knight and J. M. Gleeson. New York, Scribner's, 1900. xiii, 323 pp., 8vo. $2.50. — KORSCHELT, E., and HEIDER, K. Text of the Embryology of Invertebrates. Translated from the German by Matilda Bernard. Revised and edited with additional notes by Martin F. Woodward. Vol. iv, Amphineura, Lamellibranchia, Solenoconcha, Gastropoda, Cephalopoda, Tunicata, Cephalochorda. London, Swan, Sonnenschein & Co. New York, Macmillan, 1900. xi, 594 pp., 8vo, 312 figs. $4.50. — MICHAELSEN, W. Das Tierreich. 10. Lieferung, Vermes, Oligochæta. Berlin, Friedländer, 1900. xxix, 575 pp., 8vo, 13 figs. 35 marks. — MIGULA, W. A. de Bary's Vorlesungen über Bakterien. Dritte Auflage durchgesehen und theilweise neu bearbeitet. Leipzig, Engelmann, 1900. vi, 186 pp., 8vo, 41 figs. 3.60 marks. — MITCHELL, P. CHALMERS. Thomas Henry Huxley. A Sketch of his Life and Labors. New York, Putnams, 1900. xvii, 297 pp., 8vo. Illustrated. — PEPOON, H. S., MITCHELL, W. R., and MAXWELL, F. B. Studies of Plant Life. A Series of Exercises for the Study of Plants. Boston, D. C. Heath & Co., 1900. xii, 95 pp., 8vo. $0.50. — SCOTT, D. H. Studies in Fossil Botany. London, Adam and Charles Black, 1900. xiii, 533 pp., 8vo, 151 figs. $2.75. — TILLMAN, S. E. A Text-Book of Important Minerals and Rocks with Tables for the Determination of Minerals. New York, John Wiley & Sons, 1900. viii, 176 pp., 8vo, 38 figs. $2.00. — UNITED STATES WAR DEPARTMENT. Report on the Census of Cuba, 1899. Washington, Government Printing Office, 1900. 786 pp., plates, maps, etc. — VERWORN, M. Das Neuron in Anatomie und Physiologie. Jena, Fischer, 1900. 54 pp., 8vo, 22 figs. 1.50 marks. — WALLACE, A. R. Studies, Scientific and Social. Two volumes. London, Macmillan, 1900. ix, 532 pp., 88 figs., and viii, 535 pp., 8vo, 25 figs. (?). $5.00. — WALTER, H. E., WHITNEY, W., and LUCAS, F. C. Studies of Animal Life. A Series of Laboratory Exercises for the Use of High Schools. Boston, D. C. Heath & Co., 1900. vi, 106 pp., 8vo. $0.50. Teacher's Book of Suggestions to accompany Studies of Animal Life. pp. xxxi.

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Trans. Roy. Soc. Can. [2]. Vol. vi, sect. iv, pp. 19–48, 6 plates. — LUCAS, F. A. A New Fossil Cyprinoid, Leuciscus turneri, from the Miocene of Nevada. *Proc. U. S. Nat. Mus.* Vol. xxii, pp. 333, 334, Pl. VIII. — LUCAS, F. A. The Pelvic Girdle of Zeuglodon. Basilosauris Atoides (Owen), with Notes on Other Portions of the Skeleton. *Proc. U. S. Nat. Mus.* Vol. xxiii, pp. 327–331, Pls. V–VII. — MILLER, G. S., JR. A Second Collection of Bats from the Island of Curaçao. *Proc. Biol. Soc. Wash.* Vol. xiii, pp. 159–162. — MILLER, G. S., JR. A New Gerbille from Eastern Turkestan. *Proc. Biol. Soc. Wash.* Vol. xiii, pp. 163, 164. — MORRIS, E. L. Some Plants of West Virginia. *Proc. Biol. Soc. Wash.* Vol. xiii, pp. 171–182. — OSBORN, H. The Genus Scaphoideus. *Journ. Cincinnati Soc. Nat. Hist.* Vol. xix, No. 6, pp. 187–209, Pls. IX, X. — PERKINS, G. H. Report of the State Geologist on the Mineral Industries of Vermont, 1899–1900. Burlington, 1900, 83 pp., 29 figs. — WHITEAVES, J. F. On Some Additional or Imperfectly Understood Fossils from the Cretaceous Rocks of the Queen Charlotte Islands, with a Revised List of the Species from these Rocks. *Geol. Surv. Canada*, Mesozoic Fossils. Vol. i, Pt. iv, pp. 263–307, Pls. XXXIII–XXXIX. — WITHERS, W. A. Another Warning in Regard to Compost Pedlars. N. C. Agr. Exp. Sta., *Bull. No. 173.* June, 1900, pp. 83–116.

Brooklyn Medical Journal. Vol. xiv, No. 11. November. — *Insect World.* Vol. iv, No. 10. October. — *International Monthly.* Vol. ii, Nos. 5, 6. November. — *Journal of Zoöphily.* Vol. ix, No. 11. November. — *O. S. U. Naturalist.* Vol. i, No. 1. November. — *Popular Astronomy.* Vol. viii, No. 9. November. — *Science Gossip.* N.S., vol. vii, No. 78. November. — *Spelunca. Bull. Soc. Spéléologie.* Tome vi, Nos. 21, 22. — *Springfield Library Bulletin.* Vol. xx, No. 8. December.

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THE AMERICAN NATURALIST

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DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

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THE
AMERICAN NATURALIST

VOL. XXXV. *February, 1901.* No. 410.

SCHARFF'S HISTORY OF THE EUROPEAN FAUNA.

LEONHARD STEJNEGER.

IN a recent volume of the *Contemporary Science Series*, Dr. Scharff [1] has given us, under the above title, an elaborate attempt to trace the origin of the present fauna of Europe and to some extent also its flora. He has followed up the various migrations which have taken place in that continent chiefly since Pliocene times, and indicated the routes which in his opinion they must have followed, as well as the obstacles which barred their way in other directions. This leads to a discussion of the conditions of climate and distribution of land and water during the glacial epoch. He has thus brought face to face in one volume some of the most important problems in zoölogy, botany, and geology, and whether we agree in his conclusions or not, we owe him a debt of gratitude for the admirable manner in which he has laid the whole question before us and for the mental stimulus which his presentation of it is sure to infuse into the discussion.

[1] Scharff, R. F. The History of the European Fauna. London, Walter Scott, 1899. viii + 364 pp., 8vo, 21 figs. and maps in text.

In the introductory chapter Dr. Scharff, starting out from the present fauna of Great Britain and Ireland, demonstrates its heterogeneous composition, embracing, as it does, animals, the affinities or geological history of which point to their southern, northern, or eastern origin, and shows that in all probability the southern forms must have extended northward from the continent long ages ago, while the others arrived comparatively recently. He then discusses the means of dispersal possessed by the various animals, especially "the occasional means," as Darwin called them, and ventures to think that both Darwin and Wallace have somewhat overestimated its significance, and he reaches the conclusion that five per cent would be a high estimate for the animals which have reached British soil by accidental means. This proportion he regards as insignificant, in fact as utterly negligible.

In the second chapter, which is headed "Preliminary Considerations," Dr. Scharff endeavors to show how to determine approximately the original home of an animal so as to be able to study the component elements of the European fauna. As one of the results he announces that what was formerly believed to have been one great northern invasion now resolves itself into two distinct ones — the Siberian and the Arctic. An examination of the present distribution of mammals, snails, and earthworms shows that the British Islands have been connected with one another and with the continent; Spain with Morocco across the Straits of Gibraltar; Greece with Asia Minor, and so forth. The British fauna forms the key to the solution of the wider problem of that of Europe, five elements being recognizable, of which the Lusitanian is the oldest and the Siberian the most recent. A discussion of the climate of Europe during the glacial period follows, in which Dr. Scharff tries to maintain that so far from being of an Arctic nature the climate was mild, possibly even milder than at present, to which result he is mainly led by a contemplation of the striking and most remarkable mingling of a northern and a southern fauna during the Ice Age. An extensive glaciation, as advocated by modern geologists, is consequently denied and evidence brought forward to demonstrate the marine origin

of the boulder clay as opposed to its character as bottom moraine. Under such climatic conditions portions of the fauna and flora [1] were enabled to continue their existence in localities reached by them in preglacial times.

The British fauna is taken as a convenient starting point and is treated of in the third chapter. Examples are given of the more noteworthy forms belonging to the three foreign elements of which it is composed, *viz.*, the northern, eastern, and southern, as well as a small endemic one, and adhesion given to the almost unanimous opinion of biologists that the bulk of the British fauna and flora (biota?!) is attributable to invasions by land from the continent. As for the relative age of these invasions and the geological periods in which they entered the British Islands, Dr. Scharff feels convinced that the south-western or Lusitanian fauna, and also the flora, must have arrived before the glacial period and survived the latter. The Alpine and Oriental invasions arrived next. After these came the Arctic, and finally the eastern, or Siberian. The geological age of the latter is most easily traced because of the more complete fossil evidence at hand. As the Siberian invasion arrived in Germany after the deposition of the lower boulder clay, consequently after the first portion of the glacial period had passed, it would seem to follow that the Forest Bed in England, which geologists hold to be preglacial, must be interglacial, corresponding to the Loess formation of central Europe. The chapter concludes with statements of facts showing a continuous coast line to have existed between France and Ireland.

With the fourth chapter Dr. Scharff takes up in detail the discussion of what he calls the "Arctic fauna." The basic

[1] The author, like many other writers on similar subjects, has felt the need of a comprehensive term to include both fauna and flora which will not only designate the total of animal and plant life of a given region or period, but also any treatise upon the animals and plants of any geographical area or geological period. As such a term I would suggest *Biota*, not only because its original significance covers the above definition, but also because of its brevity and obvious relationship to the term "Biology" as embracing Zoölogy and Botany. *Biotic* would then signify "pertaining to or treating of a biota," as. — a biotic publication, a biotic region.

supposition upon which rests the whole theory of the Arctic immigration, in so far as such terrestrial animals are concerned, which require a continuous land connection, consists in the assumption that America and Europe were connected far north between Scandinavia, Spitsbergen, and Greenland until toward the end of the glacial period, while Norway again was continuous with Scotland across the North Sea, and England (and Ireland) with France. The earliest traces of such an immigration he finds in certain so-called American plants and fresh-water sponges which are found on the northern and western coasts of Ireland, in the Hebrides, in Scotland, and in North America. "The geographical distribution of some of the Arctic species is referred to in greater detail," to use Dr. Scharff's own words in his summary of this chapter, "to show how the relative age of their entry into Europe can be determined. Two forms of reindeer, resembling the Barren-Ground and Woodland varieties, have been met with in European deposits, but only the former occurs in Ireland and the south of France, whilst eastward the other becomes more common, and finally is the only one found. It is believed that the Barren-Ground is the older form as far as Europe is concerned, and that it came to us with the Arctic migration, and that the other reindeer reached Europe much later from Siberia, when Ireland had already become detached from England. The range of the Arctic hare is equally instructive. It must have been a native of Europe since early glacial or preglacial times —before the common English hare had made its appearance in central Europe. Along with other Arctic forms it entered northern Europe directly from the Arctic regions by means of the former land connection which joined, as I remarked, Lapland with Spitsbergen, Greenland, and North America." The stoat, or ermine, is another distinctly northern animal which Dr. Scharff regards as having reached Ireland and England at two different times; the one from the Arctic regions as a northern migrant, the other with the Siberian fauna from the east, and its range is made to include Greenland and Spitsbergen. He also thinks that there can be no doubt that the British grouse belongs to the northern migration, and the

ptarmigan and snow bunting are also reckoned as invaders from the north. Several other animals are mentioned as Arctic; thus the various lemmings, though it is not quite clear whether he regards these as belonging to the Arctic immigration, since they are also included in the animals constituting the Siberian contingent. The character of the flora is also alluded to as strengthening the theory of an Arctic (*i.e.*, North-America-Greenland-Spitsbergen-Scandinavia-Scotland) route, though a postglacial connection between Europe and Greenland is not insisted on, as the present flora of that country may have survived the glacial period in the Arctic regions. Professor Forbes's opinion, that the occurrence of certain shore Mollusca, both on the coast of Finmark and Greenland, shows that these two countries were not long ago joined, is alluded to, and the view that the continental boulder clay is a marine deposit is again brought forward as fitting so much better with the known facts of distribution.

The Siberian invasion forms the subject of Chapter V, in which a number of British animals, living and extinct, are traced to a Siberian origin, chiefly mammals, and some birds. Among many of the lower vertebrates and invertebrates there are but few species which in Dr. Scharff's opinion have reached England from Siberia. They may have had their original homes in the Alps, in eastern Europe, or in central and southern Asia, and have joined in their westward course the later, more quickly traveling mammals. No less than twenty-six species of the Siberian mammals, according to Scharff, penetrated as far west as the British Islands, and nine of these still inhabit Great Britain. Some of the remaining seventeen species probably lived only for a very short time in England, and the rest gradually became extinct one by one. Our author enumerates them as follows[1]: *Canis lagopus*, *Gulo luscus*, * *Mustela erminea*, * *M. putorius*, * *M. vulgaris*, * *Sorex vulgaris*, *Lagomys pusillus*, * *Castor fiber*, *Spermophilus eversmanni*, *S. erythrogenoides*, *Cricetus songarus*, *Myodes lemmus*, *Cuniculus torquatus*, * *Mus minutus*, * *Arvicola agrestis*, * *A. amphibius*, *A.*

[1] Those marked with an asterisk still inhabit Great Britain, or did so within historic times.

arvalis, * *A. glareolus*, *A. gregalis*, *A. ratticeps*, *Equus caballus*, *Saiga tartarica*, *Ovibos moschatus*, *Alces latifrons*, *A. machlis*, *Rangifer tarandus*. It will be noticed that this list contains species which have also been quoted as Arctic immigrants, in which case, however, Dr. Scharff regards them as having arrived at different times both from the north and from the east. It will also be observed that several species which from their present distribution are regarded as Arctic, — as, for instance, *Canis lagopus* and *Ovibos moschatus*, the Arctic fox and the musk ox, — are given as Siberian immigrants, the latter obviously because it has not been found in Norway, and consequently cannot have come by way of the latter country from Greenland. In discussing the route by which these animals arrived and their origin, Dr. Scharff returns to his *prætera censeo*, that a mild climate prevailed then in central Europe; and in reply to Nehring's "steppe theory" he states that we have really no idea under what precise climatic conditions the Siberian mammals lived in their original home, and offers evidence from other synchronous animals, such as the mollusks, to show that they afford no proof of a steppe character of the country at the time when they were alive. Additional support is derived from the evidence of a connection between the Caspian and the White Sea which would have prevented the Siberian fauna from spreading westward in Pliocene and early glacial times. But on disappearance of the marine connection a way would have been opened into central Europe. The marine character of the boulder clay is again reverted to, and the age of the English Forest Bed determined as interglacial, contemporaneous with the German interglacial beds also containing the bones of these Siberian migrants.

While the so-called Siberian invaders came from the east, they entered Europe by a more northern route than a large number of animals which also came from Asia, but by way of Asia Minor. They compose what Dr. Scharff calls the Oriental migration, which is treated of in detail in Chapter VI, and of which he himself has given the following summary:

"They originated in central, southern, and western Asia. It is not easy to discriminate in all cases between the Oriental

migration and the Siberian. To a certain extent, even an entry of northern Asiatic species has taken place by the southern route, and *vice versa*. On the other hand, southern species might have come to Europe by the southern route — that is to say, to the south of the Caspian — and also by the northern, which lay to the north of that great inland sea. The red deer [*Cervus elaphus*] is a good example. It arrived on our continent by both routes. However, there is a racial difference in the members of the two migrations. The small race now found in Corsica, Sardinia, northwest Africa, and western Europe is probably the older of the two, while the larger one — resembling the American wapiti deer — arrived very much later from Siberia.[1]

"The mammoth, wild boar, badger, the dippers, and pheasants are all Oriental species which have come to us from the southeast; but there are also reptiles and amphibians, and a host of invertebrates. Not all the animals, for instance, which have reached us in England from the southeast are of Asiatic origin. There is an active center of distribution in southeastern Europe itself, from which species radiate out in all directions. This fact is well illustrated by the genus Clausilia. Species from this center, and also from the Alps, joined the Oriental stream in their northward course.

"In reviewing a number of instances of Oriental species in Europe one is struck by the peculiarity of their having apparently followed two distinct routes. All entered from Asia Minor, which is proved to have been connected with Greece until recent geological times. From here some seem to have proceeded straight west, others northward. Further study reveals the fact that the first route was followed by a much older set of migrants at a time when the Mediterranean area was greatly different from what it is at the present day. Greece was then joined to southern Italy, Sicily, and Tunis. The latter was also connected with Sardinia and Corsica, and the Straits of Gibraltar did not exist. Under such geographical

[1] On page 250 it is stated that it appears that it (*i.e.*, the larger race of deer) also reached England. *Cervus elaphus* is not enumerated by Dr. Scharff, however, as one of the Siberian migrants on page 202. — L. S.

conditions a direct migration on land from southern Greece to Spain was not only possible, but was actually undertaken by a very large number of Oriental species."

Chapter VII treats of the Lusitanian fauna in detail. As already mentioned, Dr. Scharff regards this element as the oldest in the British Islands, its antiquity being indicated by the discontinuous distribution of so many of its species. As Lusitanian, he regards species having their origin in the southwestern portions of Europe, "or on the mysterious lands which lay beyond it." Not all the species which have entered Great Britain from that direction, however, are true Lusitanian, inasmuch as many of the Oriental invaders are supposed to have traveled as far as Spain by way of the Mediterranean route, and then, proceeding northward, to have reached France, Ireland, and England. Only one mammal is treated of as undoubted Lusitanian, *viz.*, *Oryctolagus cuniculus*, the rabbit; but several birds are mentioned as having a southwestern origin, prominent among which are the Dartford warbler (*Melizophilus undulatus*), the pied wagtail (*Motacilla lugubris*), and the genus Fringilla. Among the lower vertebrates there are more species of this kind. Thus the ancestors of the amphisbænian lizard (*Blanus cinereus*) are supposed to have entered Europe by way of the sunken "Atlantis"; other probable Lusitanians are the Discoglossoid toads and the salamandine genus Chioglossa. Various butterflies, beetles, and spiders may be similarly traced to a southwestern origin, but especially a large number of land mollusks, notable among which is the spotted slug (*Geomalacus maculosus*), which is known only from Portugal and few localities in southwestern Ireland.

The Alpine fauna forms the subject of the last chapter, the eighth. The history of this part of the fauna begins with the rise of the Alpine island in the Miocene sea. This island, being first connected with the mainland to the east, naturally received its first inhabitants from that direction; and Dr. Scharff regards them as having formed part of the older Oriental invasion, many species of which, by long isolation and the elevation of the Alpine country, became modified into very distinct species, thus forming as it were a new fauna.

At least this is the way I understand Dr. Scharff when he speaks of indigenous Alpine species. Following these came the newer Oriental invasion. During Pliocene times dry land gradually supplanted the sea to the north of the Alps, and their Biota (fauna and flora) poured into the plain. At that period Arctic species from the north (*via* Scandinavia, Great Britain, and France) and Lusitanian forms from the west found their way to the Alps. The true Siberian types came much later, *viz.*, in the Middle Pleistocene, making their appearance at the foot of the Alps, though it is doubtful whether many of them ever reached the mountains. Thus he accounts for the presence of the so-called Scandinavian species in the Alps, and *vice versa*, in two ways — first, an early northern invasion directly from Scandinavia to the Alps *via* England, and, second, by both Scandinavia and the Alps receiving a share of the Siberian colonists, parts of which went north, while others went south. Dr. Scharff is thus led to disagree with Forbes's theory, once quite generally accepted, that this similarity between the mountain faunas of northern and southern Europe was due to a gradual forcing south of the northern species and north of the southern ones by the expanding glaciers on both sides, by their mingling in the intermediate territory and subsequent retreat to their old homes when the glaciers receded, the northern forms mixed with some Alpine species and *vice versa*. Nehring's Tundra theory is also dissented from in so far as it regards the Siberian animals as forming the nucleus of the faunas of these two areas. Dr. Scharff ends the summary of this chapter, and thus the book, with the following remarks: "One of the most important conclusions obtained by this study of the flora in conjunction with the fauna, is that I have emphasised in most of the preceding chapters — *viz.*, that the glacial period in Europe was not a time of extreme cold, and that its destructive effect on the animals and plants was by no means such as is currently believed."

This last sentence is in a measure a clue to Dr. Scharff's whole book, which must be read in the light of it. It must be admitted that he has made out a good case, from the

standpoint of the biologists, against the view that would ascribe to the glacial period so severe a cold and so enormously and universally developed an ice sheet, or ice cap, that all life became extinct and every inch of ground hidden by a thick covering of perpetual ice. I doubt, however, that this is currently believed by the biologists of to-day. I do not think I am much out of the way when I say that most of us regard the conditions and climate of the Ice Age in Europe to have been on the whole much like the conditions and climate of Greenland and the island world north of Hudson Bay at the present time. It would therefore be possible for us to subscribe to Dr. Scharff's conclusion as above worded were it not that in the book itself he goes much farther, requiring, as he does, a climate in central Europe at least as mild as that of the present day or even milder. The present reviewer at least cannot admit that the known facts relative to the distribution of animals and plants during Pliocene and Pleistocene times require such a hypothesis for their satisfactory explanation.

It may be true "that with a comparatively slight change of the atmospheric conditions in the British Islands, we might have glaciers back again on all our highest ranges in England, Scotland, and Ireland" (p. 69), and it may also be true that Falsan, whom Dr. Scharff quotes with evident approval, is right when he says "that the mean annual temperature of France during the glacial period was approximately from 6–9° C., perhaps more. This," Dr. Scharff continues, "is the actual mean annual temperature of the southwest of Sweden and Norway, or the north of Scotland." Of course this statement is correct enough, but the whole question assumes a somewhat different aspect when we consider that the temperature indicated by Falsan means a lowering of the annual temperature of about 5°. This would mean for Berlin a July isotherm like that of Archangelsk; for Berlin and Vienna, a January isotherm like that of the south end of Greenland and an annual isotherm like that for the country between Sitka and the Aliaska peninsula. Under the same conditions Edinburgh would have a summer like the extreme

northern Iceland and Bering Straits and a January temperature like that of Reikiavik.

On page 183 Dr. Scharff makes the following statement: "Everybody knows that northern and Arctic species can live perfectly well in a temperate climate, but that it is almost impossible to acclimatize southern animals in an Arctic or even temperate one. We have in this circumstance almost a proof, therefore, that the climate cannot have been very cold. Though a cold sea bathed the shores of eastern England, and even eventually invaded a portion of northern England, the warm ocean on the west must have effectually prevented any great lowering of temperature." Of course a good deal depends on what we understand by "great." At the period of which Dr. Scharff treats he admits that a cold Arctic current came down along the eastern base of Scandinavia, washing the east coast of England on the west and the northern shore of central Europe on the south. Now, England has even to-day a warm ocean on the west coast; does he imagine that if a cold current — like the Labrador coast current — were to strike the east coast of England the temperature of the British Islands would not be "greatly" lowered? On the two sides of the Atlantic the warm and the cold currents make a difference in the annual temperature of the countries of the same latitude of about 10° C. Such a lowering of the annual temperature in Europe east of Ireland would bring the climate of South Greenland, Labrador, and the Hudson Bay countries to middle England, Holland, central Europe, down to Vienna, the northern edge of the Black Sea, and the northern forth of the Caspian Sea; it would also render Lapland and northern Finland equal to Baffin Land, while the climate of Spitsbergen would be as severe as that of Grinnell Land or both sides of Smith Sound. Under similar conditions France and northern Italy would have the same yearly temperature as Newfoundland, Winnipeg, and the Aliaska peninsula. The conditions which must have prevailed in Germany when land and water were distributed approximately as indicated by Dr. Scharff on his map on page 170 remind one strikingly of a combination of Hudson Bay and Baffin Bay, a combination certainly not

liable to ameliorate the climate which in the adjoining countries cannot have been much different from that of Baffin Land. This conception is of course widely different from an absolutely unbroken ice sheet with a temperature destructive of all higher life, but it is also greatly different from the idea of Dr. Scharff. Moreover, it is not inconsistent with a possibility of even a considerable number of southern forms having survived the glacial period in various sheltered nooks and corners. The humming bird occurs even as far as Sitka, almost in sight of the gigantic glaciers, and forests are known to grow above a substratum of ice. The Lusitanian species in Ireland may well have survived the glacial period, even including the spotted slug (*Geomalacus maculosus*). The fact that it occurs in Cork and Kerry Counties of Ireland to-day does not prove that it lived there throughout the glacial period, and that consequently the glacial climate was mild or milder than now, for on page 156 Dr. Scharff has a chart showing Ireland to have extended probably a couple of hundred miles farther south, this extension forming a large peninsula which must have been washed on both sides by comparatively warm currents. It is quite possible that the more tender species of the Lusitanian fauna enjoyed here a congenial climate during the greatest glaciation, retreating to their present stations in Ireland as the sea rose and the glaciers receded. It is therefore scarcely necessary to postulate a temperate climate for Europe during glacial times. Not only did considerable changes of the climate take place during that period over large areas, but there must of necessity also have been a great variation inside this vast area according to local conditions, while in the adjacent countries not directly subjected to the glaciation these local variations must have been vastly greater. We see even to-day isolated spots having a southern temperature within the limits of countries with a northern climate, and on the other hand similar northern oases in regions bounded by isotherms indicating a southern climate.

One of the principal reasons which has led Dr. Scharff to assume such a mild climate in Europe at that time is the mixture of southern and northern forms in several deposits.

The occurrence of the bones of the hyena, the reindeer, and the hippopotamus in the same caverns at Kirkdale, of the lion and northern voles near Paris, of "the mammoth, the woolly rhinoceros, horse, ox, reindeer, Arctic fox, lemming, and Pica" in the same deposit at Thiede, seems to him ample proof of a southern climate, as he is of the opinion that a northern species can much easier exist in a southern climate than a southern species in a northern one. Dr. Scharff continues (p. 74): "If, in a central European deposit, occurs a mixture of northern and southern forms of animals, the presence of the latter is more remarkable than that of the former. Logically, we should look upon the occurrence of southern species in the north, therefore, as supporting the view that a mild climate had induced them to travel northward." In order to show, however, that this "extraordinary mixture of northern and southern types of animals" is no indication of a warm climate, I will call Dr. Scharff's attention to the fact that we have a striking example even at the present day. It may seem a paradox to many, yet it is a fact that there is a district in eastern Asia where the tiger[1] (which we are used to regard as much a tropical animal as the lion and the rhinoceros) hunts the wild reindeer. That part of Manchuria where this "extraordinary mixture" occurs has an annual temperature of between 0 and – 2° C.; in other words, like south Greenland, south Labrador, and central Kamchatka. Surely, this woolly tiger might easily have lived at Thiede during the glacial period at the time of the deposition of the bones of the mammoth, the woolly rhinoceros, etc., and it is just as sure that the presence of its tropical bones in the German deposit would not prove that central Europe then had a subtropical climate.

It seems to me that Dr. Scharff's whole train of reasoning in this matter rests on a misconception. I have above quoted the following axiom of his: "Everybody knows that northern and Arctic species can live perfectly well in a temperate climate, but that it is almost impossible to acclimatize southern animals in an Arctic or even temperate one." On page 74 he

[1] *Felis tigris mongolica* (Lesson).

says: "Breeders of animals and those acquainted with zoölogical gardens know perfectly well that it is much easier to keep a northern species in a southern climate than a southern species in a northern one." Similarly he returns time and again to the curious delicacy of Arctic plants in botanical gardens as a proof that their presence in central Europe during glacial times is no evidence of an Arctic climate. He even adduces the fact that *Dryas octopetala*, one of the most typically Arctic plants, grows wild in profusion on the coast of Galway, in Ireland, at sea level, as strengthening "the view, not only that the Alpine flora is of preglacial origin, but that the climate of Europe during the glacial period was mild."

That the Arctic and Alpine floras survived the glacial period there is but little reason now to doubt, but that conclusion is not inconsistent with an Arctic climate in which all these plants even now flourish. But from this admission to the assumption that the climate was mild is a long cry and the two conclusions are not logically connected. Much less is the inference justified, which Dr. Scharff evidently draws, that the animals and plants which we now find characteristic of the Arctic regions originated during the glacial period during the mild climatic conditions and afterwards were driven off into the Arctic or the Alps by more vigorous invaders from Siberia accommodating themselves to the much severer climate. With regard to the plants, here are Dr. Scharff's own words (p. 239): "This fact [*i.e.*, the difficulty of wintering these plants in the Botanical Gardens] suggests that the Alpine and Arctic plants really did not originate in countries with cold temperatures. They probably made their first appearance long before the glacial period — perhaps in early Tertiary times — chiefly in the Arctic regions, which at that time had a mild climate. They have since become adapted to live in cold countries where they flourish, provided they receive sufficient moisture in the summer, and are protected from severe frost in the winter by a covering of snow." Apart from the fact that this theory is diametrically opposed to his own idea of the difficulty of southern species to accommodate themselves to a northern climate, as expressed above, both views, and in fact the whole

argument, rest upon the fundamentally wrong idea that whole assemblages of species — or single species for that matter — can accommodate themselves to so different conditions without changing their specific identity. Surely the examples which Dr. Scharff mentions, while referring to the difficulty of keeping southern animals and plants alive in northern climates, and, *vice versa*, the greater ease with which northern animals survive in temperate countries, refer to individuals only, though he speaks of species. It is a pretty well established fact by this time that the distribution of an animal or plant (species) is limited within a certain life zone beyond which it cannot proceed with impunity, and that this life zone is bounded by certain isotherms of the propagating season, boundaries which may differ with each species but which are fairly inflexible within the species. This *law*, which Dr. Merriam has so successfully defined and elaborated, renders it certain beyond a doubt that the presence in central Europe of a breeding and propagating assemblage of animals and plants practically identical with that of the Arctic and sub-Arctic regions of to-day indicates a corresponding climate during the propagating season; in other words, the life zone of these Arctic and sub-Arctic species was at some period during the glacial epoch located in central Europe, plants, animals, temperature, and all.

Another reason for Dr. Scharff's adoption of the theory of a mild glacial climate is the alleged marine origin of the boulder clay. Various deposits of marine invertebrate fossils in stratified beds are cited as proof that the boulder clay is not of the nature of a ground moraine. While this question probably is one in which the geologists are more directly concerned, I may say that, in my humble opinion, the most reasonable explanation is that the boulder clay is of a dual origin, — that part of it is deposited on land by the ice sheet, while other portions were formed at the bottom of the sea, dropped by floating ice and bergs. There can be but little doubt that the enormous weight of the Scandinavian ice cap depressed the land to the south of it, so as to bring it under the level of the sea. There was probably always a more or less extensive sea skirting it to the south and east, preceding the glaciers as

they extended southward, following them in their retreat to the north, receiving and distributing the ice floes and icebergs with their deposits in various places according to the varying conditions, such as changes in currents and winds and the oscillations of the rise and fall of the earth's crust. A sea like that, shut out from connection with the Atlantic Ocean to the west, only connecting with the Arctic Sea to the north, and fed by the melting ice and snow of the surrounding countries, would present features something between the Baltic and Hudson Bay. Its waters would naturally be brackish, and consequently deficient in marine life, except in a few favorable localities. The supposition of such a sea would meet all the requirements the biologists can put to it; it would explain the varied conditions of the boulder clay and the presence as well as the scarcity of the distinctly marine deposits. It would also meet their demand for an effective barrier north of the Caspian Sea to the invasion of Siberian forms during the earlier part of the glacial period, as a combination of glacier and sea is as effective for this purpose as either of these agents alone. On the other hand, it certainly cannot be taken as an indication of a mild climate, possibly milder than our present one.

While I have thus been unable to accept one of Dr. Scharff's more general and fundamental propositions, *viz.*, the one which relates to the glacial climate, there is another of his more special conclusions from which I must also dissent, *viz.*, the northern origin of the invasion, which he styles the Arctic migration.

As already explained above, Dr. Scharff accounts for the presence of certain Arctic animals in Ireland, Scotland, and other parts of western Europe, including the Alps and the Pyrenean peninsula, by a supposed immigration from America, *via* a continuous land connection between Greenland, Spitsbergen, Norway, Great Britain and Ireland, and France, this immigration being only subsequent in age to the Lusitanian fauna, and distinctly older than the Siberian immigration, which came to Europe much later from the east, though also consisting, to a great extent, of northern types closely allied to those composing the Arctic invasion.

There is at once a fatal objection to this theory, *viz.*, that there can have been no such land connection during Pliocene or Pleistocene times between Greenland and Spitsbergen. It was formerly generally believed that the Arctic Sea was a fairly uniformly shallow basin, but as one of the most important results of Nansen's *Fram* expedition we know now that the sea north of Spitsbergen and Francis Joseph Land is very deep, certainly more than 1600 fathoms, while to the west of Spitsbergen, between it and Greenland, we have soundings as deep as 2650 fathoms. A wide channel between these countries, certainly not less than 1500 fathoms in depth, connects the North Atlantic deep with the polar basin. It can be said with the utmost certainty that an elevation sufficient to bridge this and thus connect Greenland with Spitsbergen has not existed during the geological periods mentioned.[1] It is highly probable that the extreme elevation in that part of the world at that time did not exceed the present 300-meter line. At all events, there must have been a gap between land and land of at least 150 miles, a distance quite sufficient to bar all migration of the mammalia which Dr. Scharff includes in his Arctic fauna.

But apart from this insuperable barrier, there is a good reason why Spitsbergen cannot have been in the route of these animals, *viz.*, that with one exception they do not occur in Spitsbergen, nor were they ever known to occur there. The Arctic hare is certainly absent, and the records of a lemming and the ermine are highly dubious. Even if it should be true that a lemming occurs there, it is pretty safe to say that it is

[1] It will scarcely do to regard the dead shells of shoal water forms, such as *Yoldia arctica*, which the Danish "Ingolf" expedition in 1896 dredged between Iceland and Jan Mayen Island in depths between 500 and 1300 fathoms, as proof of a corresponding depression since glacial times. It is incredible that these dead shells which are scattered all over the surface of the bottom of the North Atlantic Ocean should have been lying there loose all these thousands or ten thousands of years without being covered up or destroyed. I certainly agree with those who hold that these shells have been dropped there by shore ice floated out to sea. It will be noted, moreover, that even the supposition of an extreme rise of 1300 fathoms does not affect our argument as to the continuity of Greenland and Spitsbergen, since they would still be separated by a deep channel at least 150 miles wide.

Cuniculus torquatus, the presence of which would rather work against Dr. Scharff's theory, since it does not occur in Scandinavia at all. The Spitsbergen reindeer, on the other hand, is so different from the one of Norway that it does not seem probable that one is the lineal descendant of the other. Add to this that the sea between Norway and Spitsbergen is more than 300 meters deep, and an exchange of terrestrial mammals between these two countries becomes highly improbable.

Before proceeding any farther I wish to state that while disagreeing with Dr. Scharff in his supposition of a continuous connection between Greenland and Spitsbergen and between the latter and Norway, over which his Arctic invaders might have traveled, I am in full accord with him in regard to the land bridge between Norway and Great Britain across the North Sea, and also in his conclusion that most of the immigrants which he designates as Arctic belong to an invasion different from and considerably older than the great Siberian immigration. That I also accept the continuity of Great Britain with Ireland and France, the breaking down of this connection between the two former prior to that between England and France, goes without saying; but I do not exactly agree with him in his views as to all the higher vertebrates which he attributes to this invasion.

To any one who is familiar with the present and past distribution of the Norwegian lemming (*Myodes lemmus*[1]) it must be somewhat surprising to find it included by Dr. Scharff among his Siberian colonists, rather than among the Arctic invaders. The reasons are obvious, *viz.*, first, because this rodent does not occur in America and Greenland, whence the Arctic invasion is supposed to have come; second, because it has not as yet been found fossil in Ireland, where, according to the theory, it should have occurred if it arrived in Great Britain before the land connection with Ireland broke down, an event later than the arrival of the Arctic invaders according to Dr. Scharff's chronology. This negative evidence, however, would have been counterbalanced, I imagine, by the fact that remains

[1] I adhere in this review to the nomenclature used by Dr. Scharff without regard to my own preference in the matter, in order to avoid confusion.

belonging to the Norwegian lemming type have lately been discovered in Portugal, since it is one of Dr. Scharff's criteria of a Siberian migrant that it does not occur south of the Alps or Pyrenees, were it not for the impossibility of ascribing an American origin to this species. As I have shown that none of the other Arctics can have come that way, and as the lemming otherwise agrees so well with them in their present and past distribution, I think there can be no difficulty about referring them to the same category.

Nor can I endorse Dr. Scharff's treatment of the various ptarmigans (Lagopus). On page 336 he sums up his conclusions to the effect that "*L. albus* and *L. mutus* appear in our continent chiefly[1] as Arctic migrants." His reason for so regarding the former is given on page 334, where it is stated that "no doubt the British grouse is a descendant of the Scandinavian willow grouse. The latter is known also to inhabit Greenland and Arctic North America, and is even found beyond Bering Straits in northern Siberia." In the first place, as the British grouse (*Lagopus scoticus*), with its brown wing-feathers, is almost certainly nearer the original common ancestor of the willow grouse,[2] it would be the Scandinavian willow grouse (*L. albus*) which must be regarded as the descendant, if there really be a direct line of descent between the two, and not *vice versa*. In the second place, it is easy to show that the geographical distribution of *L. albus* is not that of an Arctic species in Dr. Scharff's sense. It will be noted that he gives Greenland among the localities where this species is found. But it is one of the peculiarities of the distribution of this species that it does not occur in any part of Greenland. It is also absent in Spitsbergen and Iceland, and a route of immigration from America by any one of these countries is consequently out of

[1] On page 334 he regards the latter both as Arctic and Siberian; see also page 142.

[2] The probability that the dark wing color of *L. scoticus* might be the result of reversion is very remote. In a species so variable in its coloring we should in such a case expect a very frequent cropping out of so universal a character immediately and comparatively recently preceding the last change. It must be remembered that the white wing-feathers are characteristic of all the other species and forms of the genus, and that they are not subject to seasonal color changes like the rest of the plumage.

the question. Altogether this species is not found in most of the truly Arctic regions, as it is absent, not only in the above-mentioned islands, but also in Novaya Zemlya, Francis Joseph Land, Taimyr Land north of 72°, New Siberian Islands, Wrangel Land, and the Aleutian Islands. Its northern limit consequently agrees almost exactly with that of the wolverine (Gulo) which Dr. Scharff counts among the Siberian invaders.

With regard to the Tundra ptarmigans (*Lagopus rupestris* and *mutus*) our knowledge is unfortunately not quite so complete, owing to the difficulty of distinguishing correctly between these two forms; but, as Palmén has already indicated, it is highly probable that the latter does not occur east of the White Sea, that in fact it is confined (with its local races) to the Scandinavian mountains with their Lapland spurs, Scotland, the Alps and the Pyrenees, while *L. rupestris* (with its various forms and subspecies) extends over the entire Siberian and North American Tundra and Barren Ground, as well as Spitsbergen, Greenland, and Iceland. The former, therefore, is nearly uniform in its distribution with *Myodes lemmus*, while the latter corresponds fairly well to that of *M. obensis* (and its local forms). The significant fact in this connection, in so far as the ptarmigans are concerned, is that both the Spitsbergen, the Greenland, and the Iceland forms belong to the Siberian and American *L. rupestris*, while the Scandinavian and Scotch (also probably subfossil English and Irish) ptarmigans, with those of Switzerland and the Pyrenees, form the *L. mutus* group. These, therefore, cannot have come from America *via* Greenland and Spitsbergen (or Iceland).

But while thus this group of animals, which Dr. Scharff has called Arctic immigrants, by both physical and distributional reasons is barred from the route America-Greenland-Spitsbergen-Norway-Scotland-western Europe, it may be pertinently asked, By what road did they reach western Europe, Scotland, and Norway?

Let us first determine where they did *not* come from. Having eliminated Greenland and Spitsbergen, there are to the northward only two countries which need be further investigated, *viz.*, Norway and Iceland.

The latter might have been dismissed in a few words, were it not that Dr. Scharff, in his history of the European fauna, practically has no reference to the fauna of Iceland, the origin of which certainly is as European as that of Great Britain itself. Almost the only allusion to the famous island is a brief paragraph to the effect that if a land connection existed between Greenland and Scotland in that direction "it must have been in very early Tertiary times." Granting that there was no such continuous land bridge any more at the beginning of Pleistocene times or even during the Pliocene, by which the larger herbivorous animals could have migrated from Greenland to Iceland and Scotland, it is evident that the conditions must have been much different from what they are indicated to be on Dr. Scharff's diagrammatic maps on pages 156 and 170, in which the present sea level is maintained at Iceland and eastern Greenland, while the continental platform is raised about 200 fathoms at the western coasts of Ireland, Scotland, Norway, and Spitsbergen. Under such a distribution of land and water Iceland, though still an island, must have been much larger, while the Faröe Islands, forming a large island of nearly the present size of Ireland, were separated from Scotland by a comparatively narrow channel, and numerous islets on the high ridge between the Faröe Islands and Iceland constituted a series of stepping-stones to the latter. Such a state of affairs would of course effectually block the way of the mammals, without being a bar to many other animals, as the birds, for instance. To any one familiar with the land birds of Iceland it is perfectly plain that it would require at least that much of an interrupted land connection to make it possible for them to have developed a highly frequented migration route across that now nearly trackless ocean. I will mention only one example, *viz.*, the large-winged race of the common wheatear (*Saxicola œnanthe leucorhoa*). This race, characterized by a length of wing of over 100 mm., is known to breed in Greenland and adjacent portions of northeastern Arctic America and to migrate in winter over Iceland, the Faröe Islands, the Shetlands, Great Britain, and probably thence along the western edge of France and the Pyrenean peninsula to Africa, returning in spring the

same way to its Arctic home. For this bird to have found a way to America there must at the time have existed a route fairly well outlined by islands more extensive and more numerous than now, and the very fact that this route of the extension of its distribution (for it belongs to an exclusively Old-World genus) became an annual migration-route points plainly to the existence of such an interrupted land bridge some time in the glacial period. However, the total absence of the reindeer, the hare, the lemming, the ermine, and the musk ox in Iceland is incontrovertible proof that the Arctic mammalian invasion into western Europe did not come by way of Iceland.

There remains then only Norway as the last possible home of these animals if they arrived from the north at all. The question, however, at once presents itself: If they arrived in Scotland from Norway by way of the North Sea bridge, by what route did they then come into Norway? It is of course out of the question to suppose that they originated in that country situated at the extreme northwest periphery of the Old World, as they are all closely allied to species of arctogæan derivation. On the other hand, there seems to have been no other land connection at that period between Scandinavia and the rest of the Eurasian continent than that with Scotland. It is pretty generally agreed that the sea then covered the lowlands of northern Russia to the east, thus effectually cutting off any communication between Siberia and Lapland. Apart from the considerations which have influenced that conclusion it would be very difficult to explain the absence from the Scandinavian peninsula of a number of both Arctic and Siberian animals had there been a land connection in that region during the earlier and middle stages of the glacial period. The total absence of *Cuniculus torquatus* and the musk ox is particularly significant.

It would then appear that we are compelled to conclude that the mammals and birds in question did not come to Great Britain and Ireland from the north at all. They certainly did not come from the west, and it is equally certain that they formed no part of the Lusitanian fauna. There seems then to be no other way by which they could have reached England

and Ireland except over the land connection with France. But how did they get into France? Where did they originally come from? Various reasons preclude any hypothesis of these animals being part of the Oriental invasions, and the offshoot of the later, the Alpine fauna. Their relationships are decidedly Siberian, not central or south Asiatic, and the lemmings, as well as the willow ptarmigan, are quite foreign to the Alps. I have already expressed my agreement with Dr. Scharff that they do not form part of the great later Siberian invasion; they were present in northern Europe long before that event, as shown by their history in the British Islands.

It goes without saying that the relationships of these Arctic animals are decidedly northern and, as already remarked, equally closely Siberian, and I have no doubt that northern and western Siberia was their home, before they invaded western Europe. I am therefore compelled to recognize two distinct Siberian invasions (or rather three, since a third one is in progress to-day) widely separated in time.

The first Siberian invasion (Scharff's Arctic) took place early, probably before the first great glaciation had reached its maximum. Neither ice nor water had yet shut off the passage north of the Caspian Sea and along the northern edge of the central European mountain ranges. Thus the Tundra reindeer, the variable hare, the ermine, the Norwegian lemming, the ptarmigan, the willow grouse, and others penetrated westward to France (and the Pyrenean peninsula) and over the then continuous England, Ireland, and Scotland to western Norway without leaving any traces in the continental boulder clay which was deposited only after they had passed. The maximum of the first glaciation then barred the further ingress of any more Siberians; the boulder clay was deposited next, and on the retreat of the glaciers or rise of the land, — or rather both, — the second Siberian invasion, among which were several of the same species as the first, took place over the boulder clay. It is my impression that the musk ox and the banded lemming (*Cuniculus torquatus*) formed part of the first invasion, but for some reason or other failed to reach sufficiently far west and north early enough to pass into Ireland or Norway. It may

also be questioned whether the willow grouse reached Norway at that time, as such an assumption would involve the dilemma of either regarding *Lagopus scoticus* as a reversion since glacial times or else of supposing the Scandinavian and the present Siberian *Lagopus albus* to have originated independently and yet specifically identically from the brown-winged ancestor, none of which propositions I am at present prepared to accept. To me it appears most probable that *Lagopus scoticus* belongs to the first Siberian invasion reaching Great Britain and Ireland only, but not penetrating to Norway, and that *Lagopus albus*, the white-winged willow grouse, belongs to the second invasion entering Scandinavia from the south. I do not know that anybody has been able to distinguish the bones of these two forms, and it appears most likely to me that the fossil remains which Milne-Edwards records from France and Italy as *L. albus* really belong to *L. scoticus*. The occurrence of the latter south of the Alps is a fairly good indication that it belonged to the first invasion. However that may be, the others must have reached Norway, where they still survive, by the above route, and while the willow grouse, the Norwegian lemming, and the Tundra reindeer died out in central Europe, the remaining species, except the musk ox and Cuniculus, saved themselves in the southern mountain ranges and in congenial parts of Ireland.

It is quite probable that several other species, members of the older Oriental invasion, joined the preglacial Siberian immigration in France. As one of these I regard the red deer of Scotland and Norway, which doubtless forms a small-antlered race, or subspecies, of *Cervus elaphus*. Its distribution in Norway is highly interesting and suggestive, occurring, as it does, only along the western coast from Stavanger up to about Namsos (65° north latitude). It is here confined to the outer coast line, chiefly to the larger islands, while it is entirely absent in the interior or eastern Norway. The deer there, consequently, is restricted to that part of the country lying to the west and north of the backbone of the great ice cap which extended from southwest to northeast across the Scandinavian peninsula during the glacial period. To the south of this ice

divide red deer occur at present only in southern Sweden, but these belong to the great central European race, and it is highly interesting to note that a subfossil antler of this large form also has been found in southeastern Norway, in Ringerike,[1] consequently on the south side of the ice divide. This large-antlered deer, therefore, probably entered the Scandinavian peninsula from the south at a much later period, while the smaller Scotch form came early across the North Sea bridge and settled on the islands off the west coast of Norway. It will be seen that this hypothesis agrees pretty well with Dr. Scharff's views, expressed on page 250, as follows: "There were probably two distinct migrations of the red deer into Europe, an older one coming from Asia Minor into Greece, which stocked Sardinia, Corsica, Malta, and North Africa in the first place, when these were still connected with one another. This same migration likewise affected western continental Europe, the Irish red deer being probably the descendant of this very ancient stock. The latter entered the island when it was still part of the continent. The later migration of a larger form came from Siberia and spread mainly over eastern and central Europe, but it appears that it also reached England, although there is no evidence of any of these Siberian deer having ever inhabited Ireland." It will be seen that the case is exactly parallel to that of the deer in Norway. Dr. Scharff also calls attention in this connection to the double invasion of the reindeer, but under my supposition that both of the latter came from the east the parallelism is still more striking.

One isolated fact appears at first sight to be antagonistic to my theory of western Norway having been invaded from Scotland and not *vice versa*, as Dr. Scharff thinks, *viz.*, the occurrence of a reindeer in Spitsbergen. I have above expressed the opinion that there was not a direct land connection between Spitsbergen and northern Norway at the time when Dr. Scharff's Arctic migration must be supposed to have taken place. Whence then did the Spitsbergen reindeer come from if not from Norway? Unfortunately, the interrelationship of

[1] Collett. *Nyt Mag. Naturv.*, Bd. xxxvi (1898), p. 360.

the various forms, or subspecies, of reindeer is as yet too imperfectly known[1] to permit us to answer this question with any degree of certainty, but I wish to call attention to the fact that the Spitsbergen reindeer (*Rangifer spitzbergensis*) is too different from the typical wild Scandinavian stock to make it probable that the former is a direct descendant from the latter or *vice versa*. On the other hand, the rise of the land in that region 300 meters would still see Norway separated by the sea from Spitsbergen, at the same time leaving the latter connected by dry land with Novaya Zemlya, and there is at present nothing known which would prevent us from assuming that the reindeer originally came to Spitsbergen from Novaya Zemlya and Taimyr Land in Siberia.[2]

In defense and elaboration of his theory of an Arctic migration by way of Arctic America, Greenland, Spitsbergen, Lapland, Dr. Scharff also discusses the travels of the insects and plants and comes to the conclusion that they argue for a land connection along this route. I think it altogether likely that such a dispersal took place, and would even call attention to the fact that the plants along the north coast of Spitsbergen show a greater percentage of Arctic-American plants than those of southern Spitsbergen as corroborative of this theory, but I must insist that an unbroken land connection is not at all necessary for the dispersal of plants and insects along that route, if currents of air and sea were favorable. Dr. Scharff in his preliminary chapter would reduce this kind

[1] If these exceedingly important questions are ever to be solved, it is necessary that they be investigated at once by some competent authority. Not only are the wild reindeer becoming scarce everywhere from excessive hunting, but they are also being mixed up in the various localities to such an extent that extreme care will have to be exercised in using whatever material can now be brought together. Thus in Norway large herds of the Lapland tame reindeer have been located on the southwestern fiells, where they mingle with the wild ones of a possibly different stock; in Spitsbergen also tame Lapland reindeer have become feral, as some of the draft animals which Professor Nordenskiold brought with him from Finmarken ran away; tame Asiatic reindeer have been brought by the thousands across Bering Straits to America, and a herd of Lapland reindeer have also been introduced into Alaska to add to the confusion.

[2] Dr. Scharff in his discussion of the migrations, etc., of the reindeer (pp. 149–158) seems to argue out of the premises that the Barren-Ground reindeer do not occur in Siberia, but this is a mistake.

of dispersal to a minimum because the many happy coincidences necessary for a species to establish itself on a distant shore must be exceedingly rare. But granting this, we must not forget that while the recorded actual observations of direct accidental transplantation and subsequent establishment are few and far between, our entire experience covers scarcely a couple of centuries, while the periods of which we here treat are reckoned in thousands, possibly tens of thousands of years. And how many lucky chances may not have presented themselves in ten thousand years! Moreover, the distances with which we have to do in the present case only look formidable in the Mercator projection, while in reality they probably did not exceed 150 miles. I believe it to be a distinct mistake to suppose that all classes and kinds of animals and plants have followed the same lines of distribution in time and space. As a matter of fact, it may be even said that there are scarcely two species which have exactly the same history. Each one must be worked out separately, and too sweeping generalizations are dangerous at the present state of our knowledge.

It is one of the distinct merits of a book like Dr. Scharff's that it makes plain these defects in our knowledge. It is a kind of stock-taking by which we find out just how our business stands. It must then be admitted with regret that the status is not as satisfactory as one might have reason to expect. There is yet a great uncertainty as to the exact and detailed distribution of many of the larger and more important animals in the Arctic regions and in Europe. The grosser facts are known of course in a general way, but they are not sufficient for the purpose. The finer details are still unknown, or if known in some isolated cases are unavailing because they are as yet only isolated. American mammalogists, for instance, have studied some of the species here treated of in so far as they relate to American forms, but this knowledge is at present a dead one, because the corresponding Asiatic and European forms are still in chaos, or *vice versa*. Dr. Scharff's book shows that there is still much necessary work to be done by the "splitter" of species and subspecies, but it also shows that this work must be done with some purpose in view and

not in the ordinary perfunctory manner for the mere naming and labeling of museum specimens. The time has come when the interrelationship and the sequence in time and space of the various subspecies must be studied. A perusal of *The History of the European Fauna* should make clear to the average describer and namer of animals that his work is only the means to an end. It brings before him the very problems for the solution of which his work is necessary, and the more conscious he becomes of the uses to which it is to be put, the better and more reliable it is apt to be performed.

I do not know whether Dr. Scharff is to be commended or not for having withstood the temptation to correlate the immigration of man into Europe with that of the other post-Pliocene mammals. The wanderings of the plants are alluded to in order to strengthen the views expressed relating to the origin of the fauna. The travels of primitive man must to a great extent have followed much the same lines as the other mammals, the same natural barriers being nearly as effective in his case as in theirs. It might be said that it would require volumes to exhaust this subject alone, but that is almost equally true of all the various groups of animals. Then again it might be objected that our knowledge of the wanderings of prehistoric man in Europe is very limited and uncertain. I think, however, it can be safely asserted that it is not any more so than our knowledge of the migrations of the animals and plants in the same period, and I venture to suggest that there is a remarkable similarity between the migrations we have discussed above and those of the various European subspecies of man.

The first point to be observed is that the dolichocephalic brunet Mediterranean, or Atlanto-Mediterranean, race in its distribution both in time and space clearly corresponds to Dr. Scharff's "Lusitanian fauna." The agreement is not only a general one, but in some details almost startling, as seen if one compares, for instance, Scharff's map on page 7 with any map showing the distribution of the brunet type in the British Islands.

The next point is the almost self-evident absence of an "Arctic immigration" by way of Greenland-Spitsbergen-Norway-British Islands. On the other hand, the "Alpine fauna," the offshoot of the Oriental immigration, is plainly represented by the brachycephalic Alpine race of unmistakable Asiatic relationship. These "round-barrow men" in their westward push reached the British Islands, though they have left but few traces, except their bones, behind them there. Ireland may have been separated at the time of their invasion, since they do not seem to have reached that island, but they penetrated to the extreme of Scotland, the Shetlands, the Faröe Islands, and, as I believe, by that route — the North Sea bridge, either yet intact or only broken to the extent of furnishing stepping-stones — to western Norway, where to the present day this Alpine population holds the extreme west coast to almost the identical extent as the red deer, a most suggestive distribution when we compare it with what has been said above about the probable route of immigration of that animal in Norway. It is true that there are traces of an Alpine population in other parts of southern Norway, especially in Smaalenene, and that a migration along the Danish peninsula has been suggested. It is even likely that part of the broad-headed dark Norwegians have come by the latter route as well, but this view is not necessarily antagonistic to the above theory.

Finally the long-headed blond Nordic, or Teutonic, race, the last to arrive, corresponds substantially to the "Siberian invasion."[1] Whether any part of this can be paralleled with the preglacial, or first, Siberian stream which I have indicated above, I am not now prepared to say, but the question should be carefully looked into.

[1] This view does not antagonize the theory of the African origin of the dolichocephalic race. On the contrary, I hold that the portion of the latter which ultimately developed into the blond branch originally expanded from eastern Africa to western and central Asia. Here, in the high altitudes, I take it, the bleaching began, which after the race joined the second Siberian invasion, became more and more pronounced as it progressed westward and northward, until it reached its extreme development of blondness at the extreme northwestern point of its range, *viz.*, in Sweden.

It will be seen that Dr. Scharff's book has tempted me even beyond its own limits. This suggestiveness must serve not only as an excuse for this transgression, but also for the length of this review. It is one of the greatest merits of the book.

UNITED STATES NATIONAL MUSEUM.

ON THE QUESTION OF AN ARBOREAL ANCESTRY OF THE MARSUPIALIA, AND THE INTER-RELATIONSHIPS OF THE MAMMALIAN SUBCLASSES.

A REVIEW OF CERTAIN PHASES OF PRESENT AND PAST OPINION.

B. ARTHUR BENSLEY.

RECENT researches have seemed to indicate that the theory, proposed by Huxley, of a genetic succession of the former representatives of the Monotremata, Marsupialia, and Placentalia, is untenable, and have thus reopened the most fundamental question of mammalian zoölogy, as to the interrelationships of the primary subclasses and the possibility of a di- or polyphyletic origin.

The recent publication by Dollo ('99) of the results of his studies on the foot structure of the Marsupialia, which he interprets as confirming the growing idea of a placental origin of the group, renders this an opportune time to review and comment upon certain features of the evidence which has lately been produced in opposition to Huxley's theory.

I. THE EVIDENCE OF AN ARBOREAL ANCESTRY OF THE MARSUPIALIA AND ITS BEARING AS INTERPRETED BY DOLLO.

The question of arboreal ancestry is of considerable importance in determining the relationships of the Marsupialia, and Dollo's results may accordingly be reviewed in some detail.

On page 191 of his paper we find the problem involved set forth as follows:

"Car si cette étude démontre que les ancêtres immédiats des Marsupiaux étaient arboricoles, il sera prouvé, du même coup, que ces Mammifères ne peuvent représenter la souche des Placentaires.

"En effet, personne ne soutiendra que *tous* ceux-ci ont passé par une phase arboricole. Et quant à ceux qui en sont là aujourd'hui, ce sont des types sporadiques, qui ont pris naissance indépendamment : la chose est évidente.

"Si, donc, la nature du pied des Marsupiaux nous amène à ce résultat, que leurs ancêtres immédiats étaient arboricoles, cette conclusion contribuera à appuyer ce que nous ont appris le placenta et la dentition du lait, notamment :

"A savoir, que les Marsupiaux constituent un rameau latéral très specialisé, et non le groupe générateur des Euthériens actuels."

The essential element of Dollo's theme is therefore an attempt to prove, by means of the structure of the foot, that the Marsupialia are primarily arboreal animals and that in respect to the possession of an arboreally modified foot they are too specialized to have constituted the source of the Placentalia.

Dollo recognizes in the marsupial hind foot certain characters of arboreal adaptation. These are (*a*) opposability of the hallux, (*b*) predominance of the fourth digit, with reduction and syndactylism of the second and third, and (*c*) recession of the claws. These characters represent successive stages in the development and perfection of a prehensile foot. Their purpose is essentially that of placing the great toe in opposition to the outer digits, notably the fourth, in order to make the foot an efficient organ for grasping and holding fast to the limbs of trees.

For convenience Dollo considers the marsupials in two series, — those which have the great toe well developed and functional, and those which have it reduced, or atrophied. This division is naturally one of habit ; the former are animals which have retained the arboreal habit, while the latter are animals which have abandoned it. In these the great toe, being no longer useful, has become reduced.

To the first series belong the American opossums (Didelphyidæ) and the Australian phalangers (Phalangeridæ). In the Didelphyidæ (Fig. 1, *a*), with the exception of the subgenera Micoureus and Philander, opposability of the hallux is

FIG. 1, *a–i.* — Schematic representations of the more important types of foot structure in the Marsupialia, as interpreted by Dollo.

a, *Didelphys nudicaudata*; *b*, *Phalanger celebensis*; *c*, *Tarsipes rostratus*; *d*, *Sminthopsis murina*; *e*, *Antechinomys laniger*; *f*, *Phascolomys ursinus*; *g*, *Perameles doreyana*; *h*, *Peragal eleucura*; *i*, *Hypsiprymnodon moschatus*. (After Dollo.) For explanation see text.

the only arboreal character presented, the other digits remaining normal. But in Micoureus and Philander there is, in addition to the opposability of the hallux, an enlargement of the fourth digit. In the Phalangeridæ (Fig. 1, *b*) there is superadded to both of these a reduction and syndactylism of the second and third digits.

One member of the Phalangeridæ, Tarsipes (Fig. 1, *c*), which is unique in many other respects, is the only marsupial presenting the latest stage of arboreal modification. Tarsipes shows, in addition to all of the arboreal characters of the typical phalangers, a recession of the claws of the fourth and fifth digits.

To the second series belong the remaining members of the Australian fauna, the dasyures and their relatives (Dasyuridæ), the wombats (Phascolomyidæ), the bandicoots (Peramelidæ), and the kangaroos and wallabies (Macropodidæ). These animals are mainly terrestrial, but they all show arboreal modifications of the foot.

The dasyures have a functionally tetradactyl foot, derived from a pentadactyl one by reduction of the hallux. Various stages of this reduction are illustrated in the family; *Sminthopsis murina* (Fig. 1, *d*), for example, shows a well-formed hallux, while *Antechinomys laniger* (Fig. 1, *e*) has none at all. Wherever the hallux is indicated, however, it is of the opposable type. As in the Didelphyidæ, this is the only arboreal character represented in the family.

In the wombats (Fig. 1, *f*) arboreal characters are more numerous. The hallux is here reduced to a tubercle, but its transverse position proves it to have been formerly opposable. In addition, there is a slight syndactylism and reduction of the second and third digits.

The bandicoots have a functionally monodactyl foot, derived from a pentadactyl one by an enlargement of the fourth digit and a corresponding reduction of the others, notably the first, second, and third. It shows all of the arboreal characters of that of the typical phalangers. The least departure from the phalangerine condition is seen in *Perameles doreyana* (Fig. 1, *g*), in which the only pronounced modification is a reduction of the

hallux. The greatest departure from this condition is seen in *Peragale leucura* (Fig. 1, *h*) and in *Chœropus castanotis*, in both of which the hallux is entirely obliterated, the fourth digit greatly enlarged, and the remaining digits much reduced.

The exclusive predominance of the fourth digit in Chœropus Dollo regards as significant evidence of former arboreal habit, since in other cases in which there is a tendency towards monodactylism, as, for example, in the horse, it is not the fourth digit which predominates, but the third. The fourth digit must have been enlarged, and the third reduced, in the Peramelidæ, in connection with arboreal habit, before the tendency towards monodactylism appeared in connection with terrestrial, cursorial habit; so that the already enlarged fourth digit became still more predominant, while the third became still more reduced.

The kangaroos and wallabies also have a functionally monodactyl foot, resembling closely that of the bandicoots, and showing a similar range of modification. The musk-kangaroo (*Hypsiprymnodon moschatus*) (Fig. 1, *i*), for example, which is the most generalized type of the family, has a foot which, like that of *Perameles doreyana*, is but little modified away from the phalangerine condition. The true kangaroos, on the other hand, have an extreme monodactyl foot, like that of the higher bandicoots.

Dollo considers separately the South American form Cœnolestes (Epanorthidæ) and the Australian burrowing form Notoryctes (Notoryctidæ). With regard to the former he quotes the description of the foot given by Thomas, as "hallux short, clawless, and not properly opposable; other digits subequal, the fourth slightly the longest." He recognizes this case as doubtful, but thinks it entirely probable that Cœnolestes also is of arboreal derivation.

In Notoryctes, finally, he finds indicated predominance of the fourth digit, and reduction and syndactylism of the second and third. These characters, he states, have not been adaptively developed in connection with a burrowing habit because they are not found in other burrowing animals, such as the moles (Talpa and Chrysochloris). They point rather to a former arboreal habit.

Dollo accordingly finds in all of the Marsupialia examined a more or less extensive arboreal modification of the foot, and from this he draws the following conclusions:

All of the Marsupialia were at one time arboreal.

In the possession of a modified foot they are too specialized to have constituted the source of the Placentalia.

They are, on the other hand, *highly modified Placentalia, in which the placenta has been lost.*

They doubtless arose from *very primitive Placentalia, in which an imperfect placentation resulted in frequent accidents, such as premature birth, and it was probably to avoid these accidents that the placenta disappeared.*

According to this conception there would be four types of development in the Mammalia, as follows: (1) An oviparous condition in the Monotremata, and formerly in the Prototheria. (2) A viviparous condition, *in which the placenta has not yet appeared; found in none of the existing forms*, but formerly present in the Metatheria. (3) A viviparous condition, with placenta, in the Placentalia, and formerly in the Eutheria. (4) A viviparous condition, *in which the placenta has disappeared, in the Marsupialia.*

II. Huxley's Hypothesis in the Light of Recent Researches.

In order to define clearly the position of Dollo and other investigators on the question of the relationships of the Mammalia, it is necessary to notice in some detail the view of Huxley as expressed in his famous paper of 1880, with which modern speculation on this subject may be said to have begun.

Huxley recognized three primary and, in a sense, hypothetical divisions of the Mammalia, which he designated as Prototheria, Metatheria, and Eutheria, these groups being represented at the present day by the Monotremata, Marsupialia, and Placentalia, respectively. The existing Monotremata and Marsupialia he regarded as highly modified away from their original types, but the most generalized of the existing Placentalia (Insectivora) as only slightly so. He

recognized a genetic succession of Prototheria, Metatheria, and Eutheria, the Metatheria being intermediate with respect to the possession of certain prototherian and certain eutherian characters, among the former notably a non-placental allantois. To the Marsupialia, in passing from the purely metatherian condition, he assigned the adoption of the following special characters: a prehensile foot, associated with arboreal habit; a marsupium; a reduced milk dentition; a foreshortened period of uterogestation.

Huxley therefore implied the following plan of succession: the Prototheria giving rise to the Metatheria, and becoming specialized as Monotremata; the Metatheria, in turn, giving rise to the Eutheria, and becoming specialized as Marsupialia; the Eutheria becoming specialized as Placentalia.

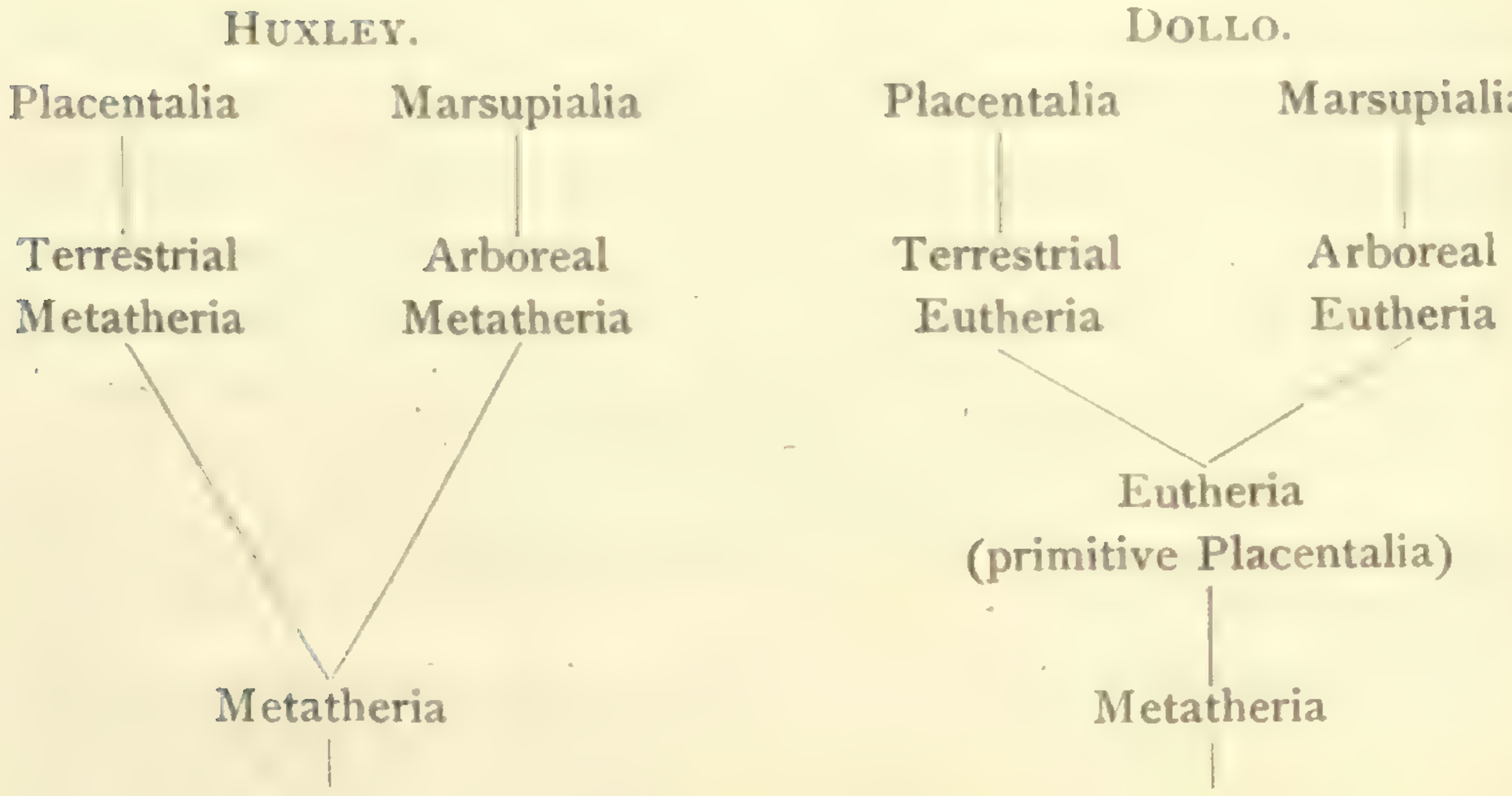
In opposition to this Dollo and others regard the Metatheria as giving rise to the Eutheria or primitive Placentalia, and the latter as giving rise, on the one hand, by retention of the placenta, to the modern Placentalia, and, on the other, by loss of the placenta, to the Marsupialia. Other investigators, notably Osborn, Hubrecht, and Seeley, recognize a separate origin of the main mammalian stems.

With this introduction we may examine certain features of the evidence on which these views are based.

1. *The Question of a Placental Origin of the Marsupialia.*

In the first place, what is the bearing of arboreal ancestry?

If we assign to arboreal habit any value as a differential character of the Mammalia, we may recognize two possible arrangements, based on the views of Huxley and Dollo, in which this factor might appear. For the sake of clearness these may be indicated in tabular form as on following page. According to the former plan arboreal habit would be associated with the differentiation of the Marsupialia and Placentalia. According to the latter it would also be an index — following Dollo — of a placental (eutherian) origin of the Marsupialia. This will make it clear that we have two distinct problems to decide: one as to the value of arboreal ancestry



as an index of a placental origin of marsupials, the other as to its value as a factor of differentiation of marsupials and placentals.

For the solution of the former we have not far to seek. We may at once accept Dollo's statement that the ancestors of the Marsupialia were, in the possession of a modified foot, too specialized to have given rise to the Placentalia, because it is impossible to make any other assumption. In doing so, however, we do not in any way compromise Huxley's view; for it must be remembered that Huxley derived the Placentalia, not from Marsupialia, but from Metatheria. The prehensile foot he regarded as a special marsupial character. On the other hand, we cannot accept the evidence of arboreal ancestry as indicating a placental origin of marsupials. It scarcely needs to be observed that the assumption by non-placental Metatheria of an arboreal habit would account for, and in as satisfactory a way, the arboreal modifications of the foot which Dollo has demonstrated throughout the existing forms.

The latter problem yields much more satisfactory results. It is on this account, in fact, that Dollo's results have been considered in detail. If the former existence of an arboreal habit throughout the Marsupialia were susceptible of decisive proof,[1] we would have a fairly reliable index of the cause of the

[1] I would regard the present evidence of arboreal ancestry as suggestive rather than as conclusive. Dollo has demonstrated conclusively that the Australian Marsupialia are of arboreal derivation, but a study of their characters, notably those of the teeth and feet, convinces me that they have arisen by a rapid adaptive radiation from opossum-like ancestors. If such is the case, they are not at

original separation of marsupials and placentals, because on a basis of arboreal habit we can explain the more important of the special characters which now distinguish the former. It is of interest to notice in this connection the opinion of Huxley: "I think it probable, from the character of the pes, that the primitive forms, whence the existing Marsupialia have been derived, were arboreal animals; and it is not difficult, I conceive, to see that, with such habits, it may have been highly advantageous to an animal to get rid of its young from the interior of its body at as early a period of development as possible, and to supply it with nourishment during the later periods through the lacteal glands, rather than through an imperfect form of placenta."[1] In other words, Huxley regarded arboreal habit as explaining two important characters of marsupials, namely the prehensile foot and premature birth. Now to these we may safely add the reduction of one of the dentitions, because, as Leche[2] has indicated, this is probably attributable to the peculiar suckling conditions which are brought about by premature birth. We may also add the marsupium; Klaatsch ('**92**) has shown that the perfect marsupium is a special character of the Marsupialia, and its perfect development in this group may best be explained on a basis of arboreal habit. Naturally these suggestions cannot be regarded as at all final, but they point strongly to an association of the special characters of marsupials with arboreal habit.

Passing by the results of Dollo, we find the idea of a placental origin of marsupials also expressed by Wilson and Hill ('**97**). These writers, in fact, originated this conception and produced what is perhaps the most significant evidence in its favor.

The valuable joint contribution of Wilson and Hill ('**97**) on the tooth development of Perameles, published in 1897, tended to confirm the idea, conceived by Huxley ('**80**), but elaborated all representative of the Marsupialia in general. In the Jurassic fauna of the northern hemisphere, and the Miocene fauna of diprotodonts of South America, we have two important groups for which an arboreal habit cannot as yet be proven.

[1] Huxley ('**80**, p. 656).

[2] Leche. *Morph. Jahrb.*, Bd. xix, p. 525.

notably by Röse and Kükenthal,[1] of the former existence of a complete double dentition in the Marsupialia, and also indicated their tooth series as directly comparable to those of the Placentalia. Prior to this the permanent antemolar series of marsupials had been regarded as homologous not with the permanent series of placentals but with their milk series.[2] The results of Wilson and Hill seemed accordingly to suggest a fundamental relationship between the two groups in respect to dentition.

Similarly, the brilliant discovery by Hill ('97) of an allantoic placenta in Perameles, which was announced at about the same time, appeared to indicate a further relationship in respect to placentation, the Marsupialia having been previously regarded as entirely non-placental.

These writers in discussing the bearing of their results, although maintaining a moderate position throughout, recognized these resemblances as primary, and indicated their preference for a derivation of the Marsupialia, by retrogression both of milk dentition and placenta, from primitive Placentalia.

Now, although it must be admitted that decisive proof of a former diphyodont condition in the Marsupialia would be of considerable confirmatory value in the presence of other evidence, it would not of itself suggest placental origin. The possibility of such a condition was clearly perceived by Huxley in advocating the reverse. On page 655 of his essay he says: "I think that there can be no reasonable doubt that the existing marsupials have undergone a like suppression of the deciduous teeth, in the course of their derivation from ancestors which possessed a full set." Huxley, in fact, astutely realized that, in order to successfully derive the Marsupialia and Placentalia, it was necessary to assume the existence of a diphyodont condition in their metatherian ancestors.

We may accordingly pass over the evidence derivable from the tooth development of Perameles and consider in detail only that presented by Hill alone from a study of the placenta of

[1] See Wilson and Hill ('97, pp. 433–438).

[2] Röse, Kükenthal, Leche; see Wilson and Hill ('97, p. 582). This view has been recently supported by Dependorf ('98).

this animal and the modifications of the allantois in other marsupials.

Prior to Hill's discovery of the placental allantois of Perameles, other investigators [1] had examined the modifications of the allantois in certain other forms. Owen, Selenka, and Semon had described for the phalangers (Phalangeridæ) and kangaroos (Macropodidæ) (Fig. 2, *c*) one condition in which the allantois was reduced and enclosed by the yolk-sac. Selenka had found a similar condition in the opossum (Didelphyidæ). Caldwell and Semon, on the other hand, had found in the koala (Phascolarctos) (Fig. 2, *b*) another condition in which

FIG. 2, *a*–*c*. — The main modifications of the marsupial allantois arranged in the order of their primitiveness as interpreted by Hill. (*b* may represent the type from which *a* and *c* have been derived.)

a, placental allantois of Perameles (from Parker and Haswell, after Hill): *b*, "respiratory" allantois of *Phascolarctos cinereus*; *c*, the reduced allantois of *Æpyprymnus rufescens* (Macropodidæ), (*b* and *c* after Semon); *y.s.*, yolk-sac; *all.*, allantois.

the allantois was well developed and freely exposed to contact with the embryonic envelope, much as in the Reptilia.

In his concluding remarks Hill considers these types and endeavors to decide as to which one of them is the most primitive; in other words, to determine whether a placental allantois is being developed secondarily in the Marsupialia, or whether the placental condition was formerly present throughout the group and has been subsequently lost in all forms (so far as known) but one.

He argues thus: that the reduced condition of the allantois is necessarily secondary; that although it is possible to derive

[1] See Hill ('97, p. 438).

the placental allantois of Perameles from one of non-placental type, like that of Phascolarctos, the reverse procedure is the more natural one, because Perameles is of more archaic aspect than Phascolarctos, and the latter is much more retrogressive in dentition; that it is entirely improbable that such a structure as an allantoic placenta should have developed twice independently in the Mammalia (*i.e.*, independently in Perameles). On these grounds he would regard the placental condition of the allantois as the primitive one for the Marsupialia and the non-placental allantois of most existing forms as secondarily derived by retrogression.

That the typical condition of the allantois has arisen by reduction, and is therefore secondary, naturally admits of no reasonable doubt, for no one would suppose that the allantois would be incipient in animals which have passed through an oviparous phase. That the evidence derivable from the organization of the Marsupialia may be interpreted as proving a reduction of the allantois from a placental to a non-placental condition is, however, open to objection, both on general and on special grounds. In opposition we may maintain that there is no possible, and at the same time legitimate, way of assuming retrogression of the allantois on a basis of retrogression in other structures, especially those of adaptive character.

On general grounds, changes in the embryonic membranes may not be closely correlated with adaptive changes (progressive or otherwise) in the general organization. For example, the modifications of the placenta in placental mammals are not directly related to the adaptive (ordinal) characters of the animals in which they occur; several modifications may occur in the same group (*e.g.*, Edentata), a condition which may possibly be due, as Hubrecht [1] has suggested, to the greater youth of the placenta as compared with other structures of the animal organization, but which is more probably due to the fact that the allantoic placenta is not directly affected by the various evolutionary factors which determine the appearance of adaptive characters in the animal.

But even admitting such a correlation, retrogression of

[1] Hubrecht ('89, p. 388).

placenta could not be assumed on a basis of retrogression in single structures. For example, if we assume retrogression of the allantois from a placental to a non-placental condition on a basis of the more retrogressive character of the teeth of Phascolarctos as compared with those of Perameles, as suggested by Hill, we may also assume the reverse on the evidence of the feet, for, as Dollo has shown, the foot type of Perameles is a direct natural advance on that of Phascolarctos.

The greatest objection, however, might be taken on the special grounds that the reduction and modification of the teeth which has taken place in Phascolarctos is not retrogressive ("decadent," Hill, p. 435) at all, but is, on the other hand, progressive and very comparable to that which has taken place in ungulate placentals; and, further, that as far as the greater primitiveness of Perameles or Phascolarctos is concerned there is little to choose, for although the former is decidedly more archaic in general dentition, its individual upper molar teeth are well evolved (quadritubercular), and its foot is much more specialized.

In all, it may be said that efforts to explain the reduction of the allantois, whether from a placental or non-placental condition, by reference to retrogression of the general organization are foredoomed to failure; for whatever may be true of the Marsupialia in general, the Australian members of the group, far from being degenerate, show a progressive adaptive radiation (doubtless made possible through freedom from competition) which parallels, and is in general very comparable to that which has taken place during the Tertiary period in placental mammals.

And in view of this a parallelism of placenta, though not genetically related to them, need not be more surprising than the extensive parallelisms in other structures. In other words, there is no adequate reason why the placental allantois of Perameles should not be regarded as *having arisen by progressive modification from one of non-placental (sauropsidan) type.*

These suggestions naturally do not imply that the placenta of Perameles is not primitive, or that in general the reduced allantois of the Marsupialia has not degraded from one of

placental type, but that, as far as present evidence goes, the alternative view is just as plausible

The question now to be decided is whether or not the latter explains the facts of the case equally well.

Admitting the reduced allantois to be secondary, and recognizing the importance of the yolk-sac stage in marsupials, is it not just as probable that the reduced allantois has proceeded from one of sauropsidan type as that it has proceeded from one of placental type? A failure, due to whatever cause, of the allantois to form a placental connection furnishes a more plausible explanation of the premature birth of marsupials than that of Dollo ('99, p. 203), which attributes it to the loss of placenta in the violent gymnastics of an arboreal life. And it thus affords a simple explanation of the reduction of the allantois, inasmuch as premature birth, instituted through the failure of the allantois to form a placental connection, provides not only for the nutrition of the embryo but also for its respiration. This condition being perfected, the allantois, which is a provision for respiration during the later embryonic stages, having its function usurped, has naturally become reduced.

Why the allantois should have failed to form a placental connection cannot at present be explained. The question naturally suggests itself, Is not this also attributable to arboreal habit? It is not improbable that there may have been something in the assumption by metatherian animals of an arboreal habit which, for mechanical reasons, may have made a placental formation impossible.

While still concerned with the former relationships of marsupials, it is of interest to notice certain facts concerning their ancestry which have been derived from paleontology.

In a recent paper on the origin of mammals, Osborn ('99) has dealt with this subject and has represented in the form of a chart the probable geological and phylogenetic relationships of the mammalian subclasses. In this the Prototheria and Eutheria[1] are depicted as primary groups in the Triassic, the

[1] Following Gill's division of 1872 (*cf.* Gill, '72). The Eutheria as defined by Gill are not assigned a placental or non-placental character. Hence they may be interpreted as equivalent either to the Metatheria of Huxley or to his Eutheria as interpreted by Wilson, Hill, and Dollo.

former appearing at a slightly later period than the latter. The Eutheria are depicted as giving rise, somewhere in the upper part of the Triassic, to the Marsupialia and Placentalia, which are represented in the Jurassic by the Triconodonta and Insectivora primitiva, respectively. The significant feature of this is the time relation which is implied by the recognition of marsupial and placental types among the Jurassic Mammalia.[1] If we may argue from the probable sequence of events, it would appear that we have an important clue to the characters of the Jurassic forms, namely the single tooth change of Triconodon, providing that the latter is comparable to that of existing forms. For if the reduction of one dentition is, as Leche suggests, attributable to premature birth, and the latter is, as Huxley and Dollo suggest, in turn dependent upon arboreal habit, then already in the Jurassic period the marsupials must have had their special characters well under way; so that the common ancestors of marsupials and placentals must be placed, as Osborn has indicated, at some time prior to the Jurassic period. Naturally this gives us no clue to a placental or non-placental origin of marsupials, but the distinction, if valid, is an important one, because it avoids the confusion which would result from an attempt to identify and characterize the common ancestors among the more complex faunas of later periods. But more especially it minimizes the importance of the arboreal characters of the marsupials of later periods and renders necessary a knowledge of the foot structure of Jurassic forms before decisive proof of arboreal ancestry may be obtained.

2. *The Question of a Polyphyletic Origin of the Mammalia.*

As indicated above, the view of Dollo, Wilson, and Hill opposes that of Huxley merely in reversing the relationships of marsupials and placentals while retaining the idea of a general continuity of the Mammalia. The views of other writers, on the other hand, substitute for continuity an independent origin and development of the main mammalian stems.

[1] Proposed in 1888; *cf.* opposite opinion of Flower and Lydekker ('91, p. 113).

Among the latter there is notably that of Hubrecht ('95), which recognizes a polyphyletic origin of the Mammalia from viviparous Amphibia.

Whether or not the embryological data on which Hubrecht bases his conclusions justify this interpretation is a question on which the writer does not feel competent to express an opinion. It may be noticed, however, that Hubrecht's results are differently interpreted by Assheton ('98), and that his hypothesis has not been generally accepted.[1]

Hubrecht cites in support of his hypothesis the results of Gegenbaur ('86), Mivart ('88), Osborn ('93), and Klaatsch ('92). These may accordingly be examined at the same time in relation to the view of Hubrecht and that of Huxley.

In the first place, Hubrecht regards the recognition by Gegenbaur and Mivart of a fundamental difference between the mammary glands of monotremes and those of the higher mammals as implying an independent origin of the two groups. In some respects this is open to a different interpretation. Gegenbaur, while emphasizing the sudoriparous nature of the mammary glands of monotremes as opposed to the sebaceous nature of those of the higher mammals, was fully aware of the limitations of this distinction, since he found on the mammary areas of monotremes some glands of the latter kind. In discussing the bearing of this he says (p. 35): "Aus solchen Verhältnissen des Drüsenfeldes kann man die Entstehung der Mammardrüsen bei Monotremen und den übrigen Säugern sich vorstellen. Bei den Einen ist die eine Drüsenart, bei den Anderen die andere zur Ausbildung gelangt." In other words, he perceived that from a diffuse condition, in which both kinds of glands were present, we may derive the monotreme condition by assuming an exclusive development of one set of glands, and the higher mammalian condition by an exclusive development of the other. The significance of this was later fully appreciated by Klaatsch ('92), on the discovery by him of both kinds of glands in the peculiar mammary pouches of artiodactyl ungulates. On

[1] A more moderate position on this subject has recently been taken by Jenkinson ('00).

page 365 of his paper he speaks of a fundamental correspondence between the artiodactyl ungulates and the monotremes in this respect.

Here we may notice the opinion of Wilson and Hill ('97, p. 579): "We do not believe that in the long run it will be found possible to maintain the essential dissimilarity of the mammary glandular organ in monotremes." This appears to be the more appropriate attitude.

With regard to the results of Osborn, Hubrecht quotes, among other statements, the following one, which he interprets as indicating polyphyletic origin: "All stem mammals were related in their double succession (of teeth), in their dental formula, and in their primitive molar form. These features point not to a succession, but to a unity of ancestry of the monotremes, marsupials, and placentals."[1]

This involves the broader question as to how convergence of type ought to be interpreted in the Mammalia; for, in addition to the results of Osborn, those of Wilson and Hill ('97) confirm convergence in dentition, those of Gegenbaur ('86) and Klaatsch ('92), convergence in the mammary glands, those of Klaatsch ('92, '95), finally, convergence in the accessory mammary apparatus. All of these suggest unity of ancestry.

If there were no convergence of type in the structures under consideration, Huxley's hypothesis would immediately become untenable, because it would then be necessary to assume a polyphyletic origin. But if we admit convergence, the chances are equally divided between genetic succession and polyphyletic origin. In order to prove the latter, however, it would be necessary to trace the converging structures back to a pre-mammalian stage. In other words, it would be necessary to prove that in progressive development certain structures diverged in character before the mammalian condition was instituted; because if any structure diverged from a type which was still mammalian, the latter would be regarded as also prototherian. None of the above-named structures have as yet been traced to a non-mammalian type.

[1] Osborn ('93, p. 20).

Finally, Hubrecht mentions the results of Klaatsch in connection with polyphyletic origin. He quotes from Klaatsch as follows: "Dadurch wird man zu der Annahme gedrängt, dass die Hufthiere sich ganz direkt an jene oben dargestellte Urform der Säugethiere anschliessen, deren hypothetische Vertreter man als Taschenthiere oder Bursalia von den Beutelthieren oder Marsupialia unterscheiden kann. Es wird denkbar, dass die Hufthiere niemals ein Marsupialstadium durchliefen."[1]

If we follow Klaatsch throughout the course of his paper, we find that he recognizes a primary condition of the mammary apparatus consisting of paired mammary pouches lodging the mammary glands. Out of these are formed independently the incipient marsupium of monotremes and the perfect marsupium of marsupials. In the artiodactyl ungulates these pouches show no signs of marsupium formation; they are converted into the tubular teat cavities. He accordingly concludes that the artiodactyl ungulates have not passed through a marsupial stage (Marsupialstadium).

Although this is doubtless a true interpretation, it cannot be regarded, as Hubrecht suggests, as pointing to polyphyletic origin; for it is not our object in contemplating polyphyletic origin to prove that, for example, the artiodactyl ungulates have not passed through a marsupial stage, but that they have not passed through a metatherian stage. The results of Klaatsch confirm that which Huxley, notwithstanding the meagerness of his evidence, perceived, namely that the marsupium is not a transitional character but a special character of marsupials.[2]

We may again refer to the opinion of Wilson and Hill ('97, p. 579). Concerning the mammary pouches of Klaatsch they speak as follows: "Such a rudimentary or primitive condition must have been characteristic of the common stock of both Metatheria and Eutheria, and was only a marsupial one in the sense that Echidna is now marsupial." From this it is clear that they do not regard Klaatsch's results as at all indicative of polyphyletic origin.

[1] Klaatsch ('92, p. 369).

[2] Huxley ('80, p. 656).

There are still to be noticed certain phases of opinion which chiefly concern the relationships of the Monotremata. In a recent paper by Osborn ('99), to which reference has already been made, we find the Monotremes separated off from the marsupials and placentals, and assigned an independent origin on a basis of their distinctness of organization. A similar view has also been expressed by Seeley ('96, '99).

Under the circumstances this view has been a most natural one. The tendency of recent research has been essentially towards the revelation of placental characters in the Marsupialia (Wilson and Hill ('97), Hill ('97)), on the one hand, and the revelation of sauropsidan (theriodont, Seeley) characters in the Monotremata (Semon ('94), Seeley ('96, '99), van Bemmelen ('98, '99, '00), Smith ('99), Sixta ('00), Hochstetter ('96), Ziehen ('97)). Thus the two groups have been naturally regarded as genetically distinct. It is probable, however, that in assigning a separate origin to them we overestimate their distance apart: in the first place, on account of the deceptive mask of placental characters which the Marsupialia, especially those of Australia, have assumed; and in the second place, because, while diligent search has been made for sauropsidan characters in the Monotremata, little has been done towards a recognition of the prototherian characters of marsupials. That the latter field is not unproductive may be seen from the discovery by Broom ('97), in a fœtal marsupial, of a distinct coracoid comparable to that of the Monotremata, and the recent results of McClure, showing that the numerous variations of the postcaval and related veins in the opossum (*Didelphys virginiana*) are all modifications of a ground type which Hochstetter has shown to be characteristic of the embryonic Monotremata.[1] Moreover, we should not lose sight of the familiar osteological characters which marsupials and monotremes have in common.

Reviewing the evidence as a whole, there seems to be no adequate reason for abandoning Huxley's hypothesis. Many of the facts which have recently come to light are rather confirmatory than otherwise, and many others, which have been

[1] These results were kindly communicated to me by Professor McClure.

regarded as antagonistic, are open to a different interpretation. Since it has not been definitely disproven, and especially since no other view has been advanced which explains all of the facts of the case as well, we may justly regard Huxley's theory as entitled to first consideration, even at the present day.

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'97 ZIEHEN, T. Das Centralnervensystem der Monotremen und Marsupialier. 1. Theil: Makroscopische Anatomie. *Zoologische Forschungsreisen in Australien und dem Malayischen Archipel.* Bd. iii, Lief. 1, S. 1–187. Jena.

For references to papers of Röse, Leche, Kükenthal, and others, on the dentition of the Marsupialia, see Wilson and Hill (**'97**, p. 582).

For references to papers of Owen, Caldwell, Selenka, and Semon, on the marsupial allantois, see Hill (**'97**, p. 438).

THE THEORIES OF THE ORIGIN OF THE ANTARCTIC FAUNAS AND FLORAS.

ARNOLD E. ORTMANN.

While preparing a report on the fossil Tertiary invertebrates of Patagonia collected by the Princeton expedition, the writer was led to collect the literature on the subject of the resemblance of the southern faunas and floras (of South America, South Africa, Australia, and the Antarctic islands), and was very much surprised by the vague and sometimes incorrect representations of the existing theories relating to this fascinating zoögeographical question. Many authors do not quote their predecessors at all, while others refer to them only in a very general way, occasionally misstating their views or giving incorrect or defective quotations. I have, therefore, tried to collect everything that has been written on this topic, and think it will be worth while to give here a condensed report on the subject.

One of the first to call attention to the resemblance of southern life, in this case to that of the flora, and certainly the first to advance a theory, was Hooker.[1] He is of the opinion that we could possibly explain the fact of the existence of identical plants in southern lands widely distant from each other by the assumption that there was once a connection of these parts by land. This theory, first expressed very cautiously, and at that time much disputed, was again more energetically propounded by Hooker,[2] and, in the last paper, with reference to the Darwinian view of the origin of species.

In the course of time this theory was almost forgotten, at

[1] Hooker, J. D. *The Botany of the Antarctic Voyage of H. M. Discovery Ships Erebus and Terror* (*Flora Antarctica*), Pt. ii (1847), p. 211.

[2] Hooker, J. D. Introductory Essay to the Flora of New Zealand (1853), pp. xxiii ff.; and On the Flora of Australia; its Origin, Affinities, and Distribution. *Botany of the Antarctic Expedition*. Pt. iii, vol. i (1859), pp. xvii and civ.

least it is not referred to by the next writers to be mentioned, whom we should regard as the founders of the theory of the Antarctica. The first of them is Ruetimeyer.[1] He states distinctly that we should take a part of the present faunas of South America, South Africa, and Australia for remnants of an old fauna that spread over a larger extent of the Antarctic continent, and that this Antarctic continent was the center of origin of a peculiar Antarctic fauna.

Practically the same idea — but without reference to Ruetimeyer — was set forth a little later by Hutton[2]; that is to say, he also assumed the former larger extension of the Antarctic continent, and its connection with the southern ends of the present continents.

In 1875 Gill,[3] relying on his studies on fishes, constructed his Eogæa, which was apparently conceived as a large continental mass, embracing Africa, South America, and Australia; but no mention is made of the Antarctica entering it.

In opposition to all these theories, which construct land bridges, where there is now deep water, Wallace,[4] consistent with his views on the permanence of land and oceans, entirely repudiates these opinions, and believes that the faunal elements common to the southern continents are remnants of a formerly more extensive distribution, and have been pushed into the southern ends of the land by the competition with other animals.

In favor of this view, Hutton[5] abandons his first theory of a connection by an Antarctic continent. But he still maintains that there must have been a connection between Australia and South America, and he constructs a bridge across the mid-Pacific, assuming a large Pacific land mass, which was

[1] Ruetimeyer, L. *Ueber die Herkunft unserer Thierwelt.* Basel, 1867.

[2] Hutton, F. W. On the Geographical Relations of the New Zealand Fauna. *Trans. New Zealand Inst.*, vol. v (1873); reprint in *Ann. Mag. Nat. Hist.*, Ser. 4, vol. xiii (1874).

[3] Gill, T. On the Geographical Distribution of Fishes, *Ann. Mag. Nat. Hist.*, Ser. 4, vol. xv (1875).

[4] Wallace, A. R. *The Geographical Distribution of Animals*, vol. i (1876).

[5] Hutton, F. W. On the Origin of the Fauna and Flora of New Zealand, *New Zealand Journ. Sci.*, January, 1884; reprint in *Ann. Mag. Nat. Hist.*, Ser. 5, vol. xiii, June, 1884.

joined, on the one side, to Australia and New Zealand, and, on the other, to Chili.

Von Ihering [1] takes up again the Antarctic communication, but at the same time he accepts, at least in part, Hutton's Pacific continent. According to him, a large land mass extended from South America across the Antarctic regions to Australia, from whence it continued into the Pacific continent, and even communicated with Asia (Archinotis). The Pacific continent was not directly connected with Chili.

While all these writers expressed their opinions on the Antarctica only in a very general way, Forbes [2] was the first to give it a more definite shape by drawing a map of it. He constructs his Antarctica by raising the land to about the present two thousand fathoms line, which results in an enormous extension of the Antarctic land masses.

In opposition to this, Hedley [3] restricts the Antarctica considerably, and admits only narrow connections of it with the other continents. He does not think that New Zealand was ever joined to the Antarctica by land, and does not believe in Hutton's Pacific continent, although a part of the Pacific islands were once connected with Australia and New Zealand. Of the latter relations he gives a map in his second paper.

Finally, Osborn [4] gives a map of the possible extent of the Antarctica by raising the land to the 3040 meters line. This attempt resembles somewhat that of Forbes, but shows a

[1] Ihering, H. von. On the Ancient Relations between New Zealand and South America (*Trans. New Zealand Inst.*, vol. xxiv, 1891), and Die Ameisen von Rio Grande do Sul (*Berlin. entomol. Zeitschr.*, Bd. xxxix, 1894). See also *Science*, v. December 7, 1900.

Von Ihering has referred to this subject in numerous other papers, and it is extremely difficult to collect all of them, since a large number have been published in out-of-the-way places. Lists of them have been given by himself in Engler's *Botanische Jahrbücher*, Bd. xvii (1893), p. 9, and *Science*, v.

[2] Forbes, H. O. The Chatham Islands; their Relation to a former Southern Continent (*Roy. Geograph. Soc. Suppl.*, vol. iii, 1893); abstract: Antarctica, a supposed former southern continent (*Natural Science*, vol. iii, 1893).

[3] Hedley, C. Considerations on the Surviving Refugees in Austral Lands of Ancient Antarctic Life (*Proc. Roy. Soc. N. S. Wales*, 1895), and A Zoögeographic Scheme for the Mid-Pacific (*Proc. Linn. Soc. N. S. Wales*, 1899).

[4] Osborn, H. F. The Geological and Faunal Relations of Europe and America during the Tertiary Period, etc., *Science*, April 13, 1900.

tendency to restrict the boundaries of this continent to reasonable dimensions, thus approaching Hedley's ideas.

Other writers have only added new facts to the material already at hand that favors the assumption of a former continental connection of the southern regions, and they have all accepted the general idea of Hooker and Ruetimeyer, without making any material change in it; therefore I do not consider it necessary to mention them here.

We may sum up all theories advanced, and put them into a table in the following way:

I. Theories assuming a land connection between the respective parts. This general idea was first expressed by Hooker (1847). It has been accepted by all subsequent writers except Wallace.

1. The land bridge is placed across the present Antarctic continent, first by Ruetimeyer (1867) and by Hutton (1873). It was accepted by Von Ihering, Forbes, Hedley, Osborn.
   (*a*) Forbes constructs his immense Antarctica (1893).
   (*b*) Hedley restricts it to reasonable limits (1895).
   (*c*) Osborn takes an intermediate standpoint (1900).
2. Gill constructs his Eogæa, a continent uniting Africa, South America, and Australia, but leaving out the Antarctica (1875).
3. Hutton connects Australia and South America by his mid-Pacific continent, but denies the existence of an Antarctic connection (1884).

II. Theory of Wallace (1876) rejecting any land connections whatever between the respective parts.

I do not want here to go into any further detail, since my only purpose is to give an account of the existing theories with proper references, and to classify them according to their contents. But I may state here that in the forthcoming report on the Patagonian fossils mentioned above, I shall accept Hooker's general idea, as well as Ruetimeyer's Antarctica theory, with the restrictions put upon it by Hedley, and thus we may call it *the Hooker-Ruetimeyer-Hedley theory*.

PRINCETON UNIVERSITY.

THE GENERIC NAMES MYRMECOPHAGA AND DIDELPHIS.

OLDFIELD THOMAS.

THERE have recently appeared in America two papers on these generic names, the one in this journal, by Mr. J. A. G. Rehn,[1] and the other, criticising the first, by Dr. J. A. Allen.[2] The points raised in both appear to me to need further discussion, especially with regard to the somewhat ready manner in which the species usually quoted as the type of each name is thrown aside as unrecognizable.

I. MYRMECOPHAGA.

With regard to *Myrmecophaga tridactyla*, which, if determinable, would admittedly be the type of the generic name, Mr. Rehn, while discussing Linnæus's references to Seba and Ray, altogether ignores the very first quotation of all, that to Marcgrave ("Tamandua-guacu, Marcgr. bras. 225"). On examination Marcgrave's animal proves to be beyond all question the great ant-eater of Brazil, and on the general principle of taking the first important reference as the basis for Linnæus's names we must clearly accept the great ant-eater as the type of the genus Myrmecophaga.

Linnæus's words, "*macula nigra a pectore versus latus ducta*" and "*cauda lata*," are also diagnostic of the great ant-eater, mistaken as are his statements about the digits and mammary formula.

It is unfortunate that the specific name, dating from the tenth instead of the twelfth edition of the *Systema Naturæ*, must be *tridactyla* instead of the familiar *jubata*; but even this

[1] *Am. Nat.*, vol. xxxiv, p. 575, July, 1900.
[2] *Bull. Am. Mus. N. H.*, vol. xiii, p. 185, October, 1900.

is a lesser evil than the transference of Myrmecophaga to the Tamanduas and the dubbing of the great ant-eater with a new generic name.

Dr. Allen says that while differing about Didelphis, he agrees with Mr. Rehn in regard to Myrmecophaga, but as he seems also not prejudiced (as I am) against dismissing old names as unrecognizable, and has probably not looked up the vital reference to Marcgrave, I do not feel justified in accepting Mr. Rehn's conclusions, even when backed by so great an authority as he is.

As a result I claim that *Myrmecophaga tridactyla* Linn. should be the name for the great ant-eater, Uroleptes and Cyclopes remaining as before for the other genera of the family.

II. DIDELPHIS.

In this case Dr. Allen most rightly refutes the necessity asserted by Mr. Rehn for calling all the large opossums Sarigua instead of Didelphis, but I fail to be convinced as to his application of the specific name *marsupialis* to the Virginian opossum. This name *marsupialis* hangs primarily on Seba's figure, and both authors claim that the latter is unrecognizable, Dr. Allen going on to make the remarkable statement that it is "not an American animal, but a species of Phalanger from Amboyna." It is true that Seba said his animal was from Amboyna, but even at that date mistakes could be made as to locality, and no one familiar with Phalanger, its general appearance, dentition, or mammary formula, could for one moment suppose that Seba's figure and description were based on a member of that genus. Among the whole of the Mammalia the peculiar arrangement of the mammæ is alone absolutely diagnostic of a Didelphis, nor have I any doubt what opossum it is meant to represent.

Seba's South American animals nearly all came, as was natural, from Guiana, and the figure will perfectly suit the ordinary dark opossum of northeast South America, for which Dr. Allen has used the name *D. karkinophaga*.

This conclusion, if accepted, will have the double advantage of retaining the familiar term *virginiana* for the Virginian opossum, and abolishing so jaw-breaking a name as *karkinophaga*.

In the necessity of renaming Philander I am compelled to acquiesce, though I may express a regret that in giving the name Caluromys Dr. Allen has departed from the modern practice of restricting the ending -mys to members of the Rodentia.

But of his transference of the species *cinereus* and *alstoni* from Marmosa to Caluromys I find it more difficult to approve, for the points that he mentions as allying them to the latter are all found in different degrees in one or other of the larger species of Marmosa, including *M. murina*, while neither *cinereus* nor *alstoni* present those which are more truly characteristic of Caluromys. The general shape of the skull of the latter, the small rounded molars, the great sabre-like canines, the curiously shaped lower jaw, and many other characters make up an *ensemble* to which, as it appears to me, neither of the species referred to shows any real approximation. I should therefore consider them both as members of the genus Marmosa.

BRITISH MUSEUM, NATURAL HISTORY.

THE APPLICATION OF DIDELPHIS MARSUPIALIS LINNÆUS.

JAMES A. G. REHN.

RECENTLY Dr. J. A. Allen published a paper, "Note on the Generic Names Didelphis and Philander" (*Bull. Amer. Mus. Nat. Hist.*, XIII, pp. 185–190), in which he takes exception to several statements recently published in this journal (XXXIV, pp. 575–577) by the present writer. A very hasty examination of Dr. Allen's paper convinced me that some of his conclusions must have been hastily formed, as they show a lack of detail.

A more painstaking scrutiny has disclosed several interesting points in regard to the references cited by Linnæus under his *Didelphis marsupialis;* as, like Dr. Allen, I have changed my views regarding the recognition of this name.

To quote from Dr. Allen: "It is a recognized rule of nomenclature that a name applied to a composite group, whether specific or generic, must be conserved for some one of its components when the group is later subdivided." With this I agree perfectly, and, as Dr. Allen argues, think we should give each reference cited under the name a close examination, the description being too indefinite to furnish anything. This Dr. Allen has done, but not as thoroughly as it should be.

To take the references mentioned above, they are as follows:

Philander Seb. Mus., I, p. 64, t. 39.

Opossum Tyson, act., 290, p. 1565.

Carigue Laët, Amer., 551.

Carigueija brasiliensibus Marcgr. bras., 222; Pis. bras., 323; Jonst. quadr., 136, t. 36.

Maritacaca Pis. bras., 323; Ray quadr., 182.

Tlacuatzin Hernand. mex., 330.

Concerning the first, the Philander of Seba, we find something of interest even if it does not affect the whole. An

examination of this work shows that if Dr. Allen had examined it closer he would have modified his statement that "the Philander of Seba . . . is not an American animal, but a species of Phalanger from Amboyna." The first part of the description of this animal is quoted from Valentino (*Amboinensis Animal.*, p. 273), and while it very probably relates to a species of Phalanger as Dr. Allen states, the latter part of the text (which is that of Seba) undoubtedly refers to an opossum. Such statements as "Caput, canino simile, longum protendit rostrum, acutisque dentibus . . . dorsum longis pilis, setaceis, atro spadiceis, hispidum est . . . cauda, longa, squamis rhomboideis tota tegitur," surely do not refer to a Phalanger. Seba makes the statement that Valentino had made a great error in describing the animal as he did; accordingly he gives his idea of the same, which, with the plate (undoubtedly a Didelphis), shows that Seba had nothing but an opossum in mind.

The second, Tyson's work, has been already closely examined by Dr. Allen, and nothing further can be said regarding it. The third reference, the Carigue of De Laët, I cannot examine, and therefore will pass over, as very likely the animal is a South American opossum which would not be identifiable.

The Carigueija of Marcgrave, Piso, and Jonston is an opossum of South American origin, but both the description and the locality are too indefinite to be considered.

The fifth, the Maritacaca of Pisonis, I cannot examine, but Ray has quoted it in its entirety, from which the same conclusions as the foregoing would be entertained.

The last, the Tlacuatzin of Hernandez (*Anim. Mex.*, p. 330, 1651), is an opossum which represents the form inhabiting the southern end of the tableland of Mexico, the Cordilleras, and Vera Cruz, as Mr. Nelson (*Science*, N.S., VIII, p. 897) has pointed out regarding *Spermophilus variegatus* Erxleben, which was based on an animal described by Hernandez. To quote from Mr. Nelson: "At the time when Fernandez made his observations the main area of Spanish occupation in Mexico was the southern end of the Mexican tableland, about the valley of Mexico, and thence eastward across the plains of Puebla, throughout the Cordillera to the hot lowlands of Vera Cruz."

According to the evidence set forth, the point is raised,—should Tyson's reference be given precedence over that of Hernandez?

Disregarding the dates of the references (that of Hernandez being forty-seven years older), we will proceed with the work by elimination.

The opossum "from Virginia" was separated by Kerr in 1792, while the southern Mexican animal, which, if it has been separated, can only be either *californicus* or *breviceps* Bennet, which were not described until 1833. The only other species of the genus which is found anywhere near the locality in question is *D. aurita*, which has not (to my knowledge) been recorded north of Guatemala. The elimination of Tyson's reference by the *D. virginiana* Kerr leaves us only the reference of Hernandez as the base of *Didelphis marsupialis* Linnæus.

ACADEMY NATURAL SCIENCES, PHILADELPHIA.

THE SNAKES OF NEW YORK STATE: AN ANNOTATED CHECK LIST.

EDWIN C. ECKEL.

No paper on the ophidian fauna of this state has appeared since Baird's "Serpents of New York," published in the *Seventh Annual Report on the Condition of the State Cabinet, Albany*, 1854. That which is now presented is merely a list of those species which have been mentioned more or less definitely as occurring within our limits.

The notes which I have added are of two classes. In the case of species whose presence within the state is doubtful, I have given the authority for their inclusion. In this connection I have endeavored to give credit, for the introduction of new species into our faunal lists, to those to whom it is due.

My own observations on the snakes of this state have been confined largely to that portion of the state which I traverse during my geological field work. With this area and with its fauna I am fairly well acquainted, having spent my summers for the past twelve years within it. I have, therefore, added a few notes upon the occurrence and abundance of the various species in southeastern New York. This area, as the term is used here, has geological rather than geographical boundaries. Roughly defined, it includes the counties of Orange and Rockland, on the west of the Hudson, and those of Westchester, Putnam, and the southern half of Dutchess, on the east of the river. It is an area of crystalline rocks, bordered on the north by a usually well marked depression based on limestones and shales. In one case at least, the herpetology seems to be affected by the geology. The rattlesnake is rarely seen outside of the Highlands, while the copperhead is abundant in the great Cambro-Silurian lowland which adjoins the Highlands on the north. The ophidian fauna of the region is rich

in both species and individuals, while in the Catskills, not far away, there is a notable scarcity of snakes.

I have adopted the terminology and classification of Cope, as set forth in his *Crocodilians, Lizards, and Snakes of North America*, though a note under the heading of *Eutænia sirtalis* expresses my dissent from his method of handling the subspecies of that group.

1. *Carphophiops amœnus* (Say).
2. *Diadophis punctatus* (Linn.).

   So far as my observation goes, very scarce in the southeastern counties.
3. *Heterodon platyrhinus* Latreille.

   Very common in sandy regions in Orange County and southern Westchester County. I have never encountered the melanistic form which has been variously described as *H. niger* and *H. p. niger*, but Cope notes a specimen from Scarboro, Westchester County, and there is now in the New York Zoölogical Park a living specimen taken in Sullivan County.
4. *Liopeltis vernalis* (De Kay).

   More common, I believe, in Orange County than east of the Hudson.
5. *Zamenis constrictor* (Linn.).

   A very common species, both relatively and absolutely, in southeastern New York.
6. *Coluber vulpinus* (B. & G.).

   Jordan (*Manual Vertebrates Northern United States*, eighth edition, p. 195) gives the range of this species as "Massachusetts to Kansas, and north." Cope, however (*Crocodilians, Lizards, and Snakes of North America*, p. 831), states that it is not known from east of Illinois, and I have been unable to find any record of its occurrence in or near New York.
7. *Coluber obsoletus obsoletus* Say.

   Occurs in Orange County (and probably east of the Hudson), though much scarcer than *Zamenis constrictor.*
8. *Pityophis melanoleucus* (Daudin).

   Included as a possible straggler over our southern border.
9. *Osceola doliata triangula* (Boie).

   A rather common snake in Orange County; less abundant, I believe, east of the Hudson.
10. *Osceola doliata clerica* (B. & G.).

    Cope quotes a specimen (U. S. Nat. Mus., No. 1407) whose locality is given as "(?) New York." As this state is far beyond the most

northern range of the subspecies, so far as any other records go, the label may be considered as in error.

11. *Ophibolus getulus getulus* (Linn.).

Baird ("Serpents of New York," 1854) states that "the chain snake is quite maritime in its northern distribution, being rarely found in the Northern States, except near the coast." De Kay had mentioned its occurrence on Long Island. In a "Catalogue of Reptiles and Fishes, from St. Lawrence County, procured for the State Cabinet of Natural History by Franklin B. Hough" (*Fifth Annual Report on Condition of State Cabinet, Albany*, 1852), I find that Dr. Hough collected specimens of this species from Rossie, St. Lawrence County, and that he quotes it as "of common occurrence in this portion of the state." These specimens cannot now be found, but I am inclined to accept the record, as John Gebhard, then Curator of the State Cabinet, had too thorough a knowledge of the ophidian fauna of the state to have allowed an obvious error to stand in the catalogue.

12. *Natrix fasciata sipedon* (Linn.).

Abundant in all the counties of southeastern New York. The normal ground color here is dark grayish to black. I have never seen individuals of the brownish or yellow-brown color described by some authors, and shown by casts at several prominent museums.

13. *Natrix fasciata erythrogaster* (Shaw).

Cope quotes a specimen (U. S. Nat. Mus., No. 9984) as from Westfield Falls, Connecticut. This is far to the north and east of the usual range of the subspecies, and may be an error in the label.

14. *Natrix leberis*.

I have never seen individuals of this species in southeastern New York, though much of my field work has been in localities which would seem to furnish a highly favorable environment.

15. *Storeria dekayi* (Holbrook).

This and the next species are abundant in southeastern New York, though both are so inconspicuous and retiring as readily to escape observation. As late as 1898 I have found a specimen of *S. occipitomaculata* on New York Island.

16. *Storeria occipitomaculata* (Storer).

Described by De Kay as extra-limital, this species was included in the fauna of the state by John Gebhard, Jr. (*Fourth Annual Report on Condition of State Cabinet, Albany*, p. 23, 1851), as specimens had been obtained by Dr. Fitch in Washington County. Three years later than this publication Baird, in his "Serpents of New York" (*Seventh Annual Report on Condition of State Cabinet, Albany*, p. 124, 1854), "formally introduced" the species as "an inhabitant of New York."

17. *Eutænia saurita* (Linn.).

In Westchester and Putnam counties this species appears to be even more abundant than *Eutænia sirtalis*. It is rarely found out of the immediate vicinity of water, though it is not so truly aquatic in its habits as is *Natrix fasciata sipedon*. On being alarmed this latter serpent will usually go below the surface, for a time at least. *Eutænia saurita*, on the contrary, when flushed from its place of concealment in the reeds or grass along the shore, will remain on the surface, not going far from the bank of the stream or pond, and watching for a favorable opportunity to regain the shore.

18. *Eutænia brachystoma* (Cope).

The single specimen on which this species is founded was taken at Franklin, Venango County, Pennsylvania. The species may, therefore, be found within our limits.

19. *Eutænia sirtalis graminea* (Cope).

No specimens are recorded from this state, and I have never seen an individual of *E. sirtalis* even approaching the coloration of this subspecies as described by Cope, but as specimens are described from both Ohio and Massachusetts, the subspecies is here included.

20. *Eutænia sirtalis ordinata* (Linn.).

21. *Eutænia sirtalis sirtalis* (Linn.).

Both this subspecies, and that immediately preceding, are common in southeastern New York. My own observations upon the various forms of *Eutænia sirtalis* occurring in New York have led me to feel that the subspecific grouping proposed by Cope is not entirely satisfactory.

In addition to those here listed we have in this state, I believe, at least two forms of equal rank with *E. s. ordinata* and *E. s. sirtalis*. Whether any of these forms of *E. sirtalis* occurring in New York are sufficiently distinct to be given subspecific rank is still, I think, an open question.

I had hoped to be in a position, before the publication of this paper, to discuss this subject in a more definite manner, but I have not been able to accumulate sufficient material to do so. This being the case, I have used Cope's grouping and terminology in this list.

22. *Eutænia sirtalis obscura*.

The type specimen of this subspecies was obtained at Westport, New York.

23. *Ancistrodon contortrix* (Linn.).

Occurs in swamps and low grounds in Orange and Dutchess Counties, but scarcer in the Highlands. Most of the many snakes annually killed as "Copperheads" are individuals of the species *Heterodon platyrhinus*, *Ophibolus doliatus triangulus*, or even *Natrix fasciata sipedon*.

24. *Sistrurus catenatus catenatus* (Raf.).

Described by De Kay as extra-limital, but added by Gebhard (*Sixth Annual Report on Condition of State Cabinet, Albany*, p. 22, 1853), as specimens had been sent in from Genesee County. There appears to be no recent definite record of their occurrence in that region.

25. *Crotalus horridus* (Linn.).

Still occurs in Orange and Rockland Counties, but very rare and possibly extinct east of the Hudson in this state. Cope notes a specimen collected in 1878 at Katonah, Westchester County; and I have been informed that one was killed in 1887 near White Plains.

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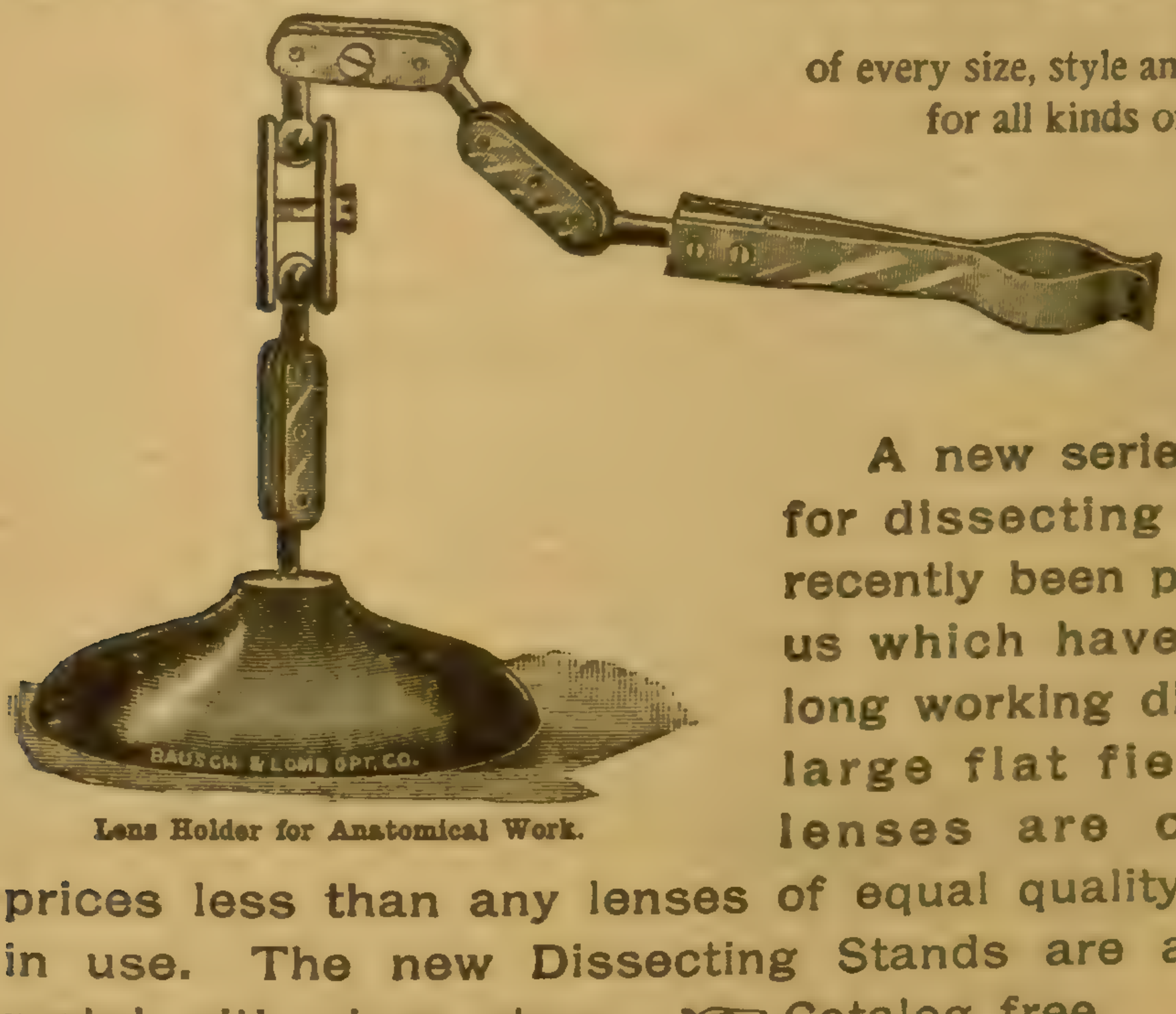

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A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

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THE

AMERICAN NATURALIST

VOL. XXXV. *March, 1901.* NO. 411.

THE MALES OF SOME TEXAN ECITONS.[1]

WILLIAM MORTON WHEELER AND WILLIAM HENRY LONG.

SINCE the observations on Eciton published in the June number of the *American Naturalist* for 1900 were undertaken, the recognition of the sexual forms of the Doryline ants has made some progress. European myrmecologists, notably Professor Forel and Professor Emery, have thrown considerable light on several of the species belonging both to the Old World (Dorylii) and American branches (Ecitonii) of the subfamily.

The doubts entertained in the senior author's former paper concerning the identity of André's *Pseudodichthadia incerta* have been dissipated. It now appears that this insect is really the female of *Eciton cæcum* Latr. In a note at the very end of his splendid work on the ants of Central America and Mexico[2] Forel quotes the following admission from a letter from M. André: "Je tiens à vous dire que je suis depuis longtemps convaincu que ma *Pseudodichthadia incerta* est bien

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, No. 11.

[2] *Biol. Cent. Am. Hymenoptera Formicidæ*, vol. iii (1899–1900), p. 160.

la femelle de l'*Eciton cæcum* Latr. J'ai été trop prudent en n'affirmant pas tout de suite cette assimilation, mais la présence d'une ☿ dans le tube contenant la ♀ et la connaissance plus étendue qu'on a aujourd'hui des Dorylides ne laissent plus aucun doute à cet égard."

Professor Emery has just published a revision of the genus Eciton.[1] For some time past he has recognized in the insect known as *Labidus latreillei* Jurine, and a number of other forms which seem to have merely varietal or synonymic value (*Labidus sayi* Hald.; *L. atriceps* F. Smith; *L. jurinei* Shuck; *L. Servillei* Westwood; *L. smithi* D. T.; *L. pilosus* F. M.; and *L. fulvescens* Blanch), the male of *Eciton cæcum*. We are, therefore, acquainted with the three phases of the commonest and most widely distributed of the ecitons, a species which ranges from Utah and Texas to southern Brazil and has been very generally known in the worker phase to entomologists for more than a century.[2]

ECITON (ECITON) CŒCUM LATREILLE.

☿? *Formica omnivora* Oliv. *Encycl. Method. Ins.*, vol. v (1791), No. 6, p. 496.
☿ *Formica cæca* Latr. *Hist. Nat. des Fourmis*, tome ix (1802), p. 270, Fig. 56.
☿ *Eciton vastator* Smith. *Journ. Ent.*, vol. i (1860), p. 71.
☿ *Eciton erratica* Smith. *Loc. cit.*, p. 71. Bates. *Natur. Amazons*, vol. ii (1863), p. 358.
☿ *Nycteresia cæca* Roger. *Berl. Ent. Zeitschr.* (1861), p. 22.
☿☿♀ *Myrmica rubra* Buckley. *Proc. Ent. Soc. Phil.* (1866), p. 335.
☿ *Eciton omnivorum* Emery. *Bull. Soc. Ital.*, vol. xxiii (1891), p. 163; *ibid.*, vol. xxvi (1894), p. 179, T. II, Figs. 9 *a–d*; *Zool. Jahrb.*, Abth. f. Syst., Bd. viii (1894), p. 258.
☿ *Eciton cæcum* Mayr. *Wien. Ent. Zeitschr.* (1886), p. 119; *Verh. zool. bot. Ges. Wien.*, Bd. xxxvi (1886), p. 440.
♀ *Pseudolichthadia incerta* André. *Suppl. aux Fourmis* (1885), p. 8, Fig. 1–5; *Spéc. Hymen. Europ. II* (1886), p. 840, fig.
♂ *Labidus latreillei* Jurine (1807); Emery, Nuovi Studi sul Genere Eciton, *Mem. R. Accad. Sci. Ist. Bologna* (1900), p. 9.

[1] Nuovi Studi sul Genere Eciton, *Mem. letta alla R. Accad. delle Sci. dell' Istituto di Bologna*, 25 marzo, 1900, 18 pp., 1 tav.

[2] The remarkable sexual trimorphism of this insect, together with its variability, at least in the worker and male phases, is largely responsible for the following interesting synonymy compiled from the contributions of Forel and Emery. For further mention of the literature the reader is referred to Dalla Torre's *Catalogus Hymenopterorum*, vol. vii, *Formicidæ*, 1893, pp. 1–7.

♂ *Labidus sayi* Hald. Stansbury's *Explor. of Utah* (1852), p. 367, Pl. IX, Figs. 1–3. Emery, *loc. cit.* (1900), p. 9.

♂ *Labidus servillei* Westw. *Arcana. Ent.*, vol. i (1842), p. 75, tome xx, Figs. 2, 2 *a*; Emery, *Bull. Soc. Ent. Ital.*, vol. xxii (1890), p. 39; Emery, Nuovi Studi, etc., *loc. cit.* (1900), p. 9.

♂ *Labidus jurinei* Shuck. Emery, *loc. cit.* (1900), p. 9.

♂ *Labidus smithi* Dalla Torre. Emery, *loc. cit.* (1900), p. 10.

♂ *Labidus pilosus* F. Sm. Emery, *loc. cit.* (1900), p. 10.

♂ *Labidus fulvescens* Blanch. Emery, *loc. cit.* (1900), p. 10.

♂ *Labidus atriceps* F. Smith. Emery, *loc. cit.* (1900), p. 16.

Both before and since learning of André's conclusion we have sought diligently but in vain for the female of *Eciton cæcum* in the vicinity of Austin, notwithstanding the species is so common that we rarely spend a few hours collecting and observing ants without happening on two or three of its colonies. These are found, as a rule, under clusters of stones which lie with their edges in mutual contact. But as the species is entirely subterranean it is not an easy matter to find the breeding chambers. The narrow burrows run along under the stones for some distance and then dip down into the soil. Frequently the galleries are found under large stones that have fallen from stone walls, and in these cases the burrows almost invariably extend under the wall where they are inaccessible to the observer. For several days after a rain *E. cæcum* may often be found under the stones in open fields, but during dry weather it seems to prefer the more sheltered and therefore moister localities. The males of *E. cæcum*, which may be readily identified by the aid of the table in Emery's latest paper, are common about the electric lights at certain times of the year. Messrs. Melander and Brues took them in considerable numbers on March 27, less frequently on April 10 and 20 of the past year. All of these specimens are referable to *Labidus sayi*, although somewhat exceeding the dimensions of the specimens described by Haldemann.

Eciton cæcum, which may be regarded as the typical species of the genus *sensu stricto* (workers with denticulate claws), is, as we have said, the only Eciton of which the male, female, and worker phases are all described. In the present paper

we wish to call attention to the discovery of the males of *E. opacithorax*[1] Emery and of *E. schmitti* Emery.[2] The male of the latter species, together with the female described in the senior author's former paper, completes the series of sexual phases of a species belonging to another natural group of ecitons (subgenus Acamatus Emery), the workers of which have smooth claws.

A male Eciton found dead in a spider's web, Oct. 3, 1899, by Mr. C. T. Brues was referred by the senior author to *E. schmitti*, mainly on account of its coloration, but it was not till October 13 of this year that it was possible to obtain positive proof of the truth of this conjecture. Late in the afternoon of the latter date Mr. A. L. Melander, Mr. C. T. Brues, and the senior author were collecting insects near Mt. Bonnel, a few miles from Austin, when Mr. Brues saw a winged ant perched on a large flat stone beneath a shrub (*Eisenhardtia amorphoides*). It was at once recognized as the Eciton of the spider's web. On drawing near, two or three other specimens were seen moving about among a lot of workers of *E. schmitti* which were issuing from a hole in the soil about the roots of the Eisenhardtia and appeared to be on the point of starting on one of the *sorties* so characteristic of these ants and their congeners. We raised the stone and found beneath it a flourishing colony of *E. schmitti*, comprising no less than a hundred of the huge (*i.e.*, when compared with the workers) winged males. Many of these were literally covered with workers and

[1] Emery (Nuovi Studi, etc., *loc. cit.*, p. 15) is now inclined to regard the former species, originally described by him as a subspecies of *E. californicum* Mayr, as a distinct species.

[2] Specimens of the species designated as *E. sumichrasti* in the senior author's former paper have been examined by Professor Emery, who pronounces the species to be the closely allied *E. schmitti* Emery. The senior author has since taken the true *E. sumichrasti* in Mexico (Cuernavaca, Morelos) and is satisfied that Professor Emery's identification is correct. On seeing the males of *E. schmitti*, Professor Emery was inclined to regard them as belonging to *Labidus nigrescens* Cresson. If this is true Emery's name of the species must be relegated to the synonomy. But some of these males were sent to Mr. Fox for comparison with Cresson's types and were pronounced to be different, being "too hairy for *nigrescens*, which is entirely brownish. The first segment of *nigrescens* is shorter and the wings light fuscous." This has induced us to retain Emery's name of the species for the present.

were being hurried by them into some deep water-worn cavities on the under surface of the stone and into the galleries which the ants had excavated in the hard soil. We succeeded, nevertheless, in capturing a large portion of the colony and in transferring it, together with some of the soil of the nest, to a strong canvas bag. The colony, first established in a large glass jar, was later placed in a Lubbock nest. The material of the original nest was searched on the spot for the pupæ of the males and for the female, but without success.[1] The following is a description of the male of *E. schmitti* drawn from fresh specimens.

Eciton schmitti Emery (Figs. 1 and 2, *b*), male. Length of body, 11–13 mm.; length of fore wing, 10–11 mm. Head, thorax, petiole, extreme base of first abdominal segment, venter, antennæ and legs, except the tarsi, black; abdomen, tarsi, hypopygium, tips of mandibles, and, in some specimens, the flagellum of the antennæ, the knees and the tips of the tibiæ fulvous red. Wings blackened, with black veins and stigma, the costa and some of the veins yellowish red at the extreme base; maxillæ and labium yellow.

Head shining, clothed with long fulvous hairs arising from coarse punctures. These hairs are longest on the vertex, posterior orbit, mandibles, first antennal joint and clypeus. Mandibles rather long, curved at the base only, slightly broadened in the middle, with convex inner edge ending in short, rather blunt points. Antennæ longer than the head and thorax; tip of the somewhat incrassated scape scarcely reaching the lateral ocellus; second joint small, remainder of the cylindrical flagellum opaque, its basal somewhat thicker than

[1] The nest contained two species of ecitophiles, *viz.*, some small trichopterygid beetles and more than a dozen specimens of a small active staphylinid with pale pronotum and elytra (*Ecitopora tenella* Wasm. *n. sp. in litt.*). Some of the latter lived for nearly a month in the artificial nest. They sought the dry portions of the nest and seemed to elude the ants by their rapid movements. They usually lurked near the entrance in cracks in the soil. When, during the morning hours, the ants were dormant in a compact cluster in the center of the nest, the beetles crept from their hiding places and moved about the galleries with less trepidation. When the ants left the nest towards evening to move about in files on the platform, the staphylinids sometimes accompanied them and then often ran off into the moat and were drowned.

its apical half; joints of approximately equal length, except at the tip, where they are somewhat longer but not compressed. Clypeus without teeth below, frontal carinæ not very prominent, separated by a distinct facial furrow. Eyes and ocelli small and not protruding. The distance between the two lateral ocelli is about the same as the distance between the lateral ocellus and the eye. Thorax gibbous in front, flattened on the dorsal surface, which is subopaque; pleuræ and pectus shining. Dorsum with fine and rather dense pleuræ, with scattered and larger piligerous punctures. Whole thorax covered with long fulvous pile, somewhat shorter and more appressed on the mesonotum and scutellum; long and erect on the pleuræ and pectus. Anterior half of mesonotum traversed by a longitudinal smooth line which seems to lie in a shallow groove at its anterior end. A somewhat similar line is found on either side, extending over the posterior two-thirds of the mesonotum, as far back as the scutellum, and another indistinct line traverses the posterior third of the scutellum, which is flat on its dorsal and convex on its posterior surface. Metanotum declivous and slightly concave on its posterior surface. Petiole subopaque above, shining below, nearly twice as broad as long, flattened transversely across the middle of its dorsal surface, but distinctly concave in front of and behind

Fig. 1. — *Eciton schmitti* Emery. Male.

this region; posterior angles only moderately projecting; anterior portion with sparse pile, posterior edges, and especially the posterior angles, with rather long, dense, and appressed fulvous pile; ventrally the pile is thin and more erect. Abdomen cylindrical, subopaque above (except at the subconstricted posterior edges of the segments which, like the venter, are glabrous), covered with minute piligerous punctures; pile on the dorsal surface of the segments short and appressed, especially towards the base of the abdomen, posteriorly and on the venter, especially in the region of the hypopygium, it is longer and more erect. Hypopygial plate shining with two short, slightly recurved teeth at its tip. Legs rather small and feeble, posterior pair not reaching to the end of the abdomen. Middle metatarsus a little more than half as long as the middle tibia. Coxæ, femora, and tibiæ shining, with rather erect fulvous pile, pile on the tarsi short and appressed. Tibial spurs red, claws with extremely rudimental denticles. Wings clothed with minute black pile, anterior pair reaching to the tip of the abdomen. For venation see Fig. 1.

On October 27 the junior author was so fortunate as to discover a flourishing colony of *E. opacithorax* Emery under a large stone in a dilapidated wall at the edge of some woods, on the sloping banks of Shoal Creek at Austin. This colony also contained a great number of males but was ransacked in vain for a queen. The workers had stored their nest with a considerable number of small carabid beetles that had evidently been captured on one of their marauding expeditions. *E. opacithorax* is considerably smaller and appears to be somewhat rarer in this locality than *E. schmitti*. We insert a description of the male, which, like the male of *schmitti*, appears to have escaped description as a species of Labidus.

Eciton opacithorax Emery (Fig. 2, *e*) male. Length of body, 10–11 mm.; length of fore-wing, 8–9 mm.

Body glabrous throughout; head, thorax, petiole, first abdominal segment, venter, femora, and tibiæ, black; lateral and dorsal regions of abdomen, including the posterior edge of the first abdominal segment, hypopygium, inner edges of mandibles, knees, and tarsi, dull red. Antennæ usually black, but

the flagellum in some specimens more or less reddish. Wings slightly blackish, covered with minute black pile; stigma reddish, veins dirty yellow. Pile covering the body grayish fulvous, long and erect on the mandibles, antennal scape, head, thorax; pleuræ, pectus, scutellum, base of petiole, and femora, elsewhere very short and appressed.

Mandibles short, covered with small piligerous punctures, curved only at the base, thence becoming broad and flat, with distinctly convex inner margin and terminating in abrupt rather blunt tips. Head covered with punctures like those on the mandibles. Eyes and ocelli very small, not projecting; cheeks and posterior orbital region broad. Lateral ocelli separated by a space about equal to that which separates each lateral ocellus from the eye. Frontal carinæ prominent, arcuate below the lateral ocelli, and separated by a rather broad longitudinal furrow. Anterior half of mesonotum with a distinct smooth longitudinal line and distinct lateral furrows extending to the insertion of the scutellum. Scutellum without a furrow on its posterior surface. The piligerous punctures covering the mesonotum and scutellum are small and evenly distributed, those on the pleuræ a little larger and more scattered. Metanotum declivous, slightly concave, finely punctate, and bearing little pile. Petiole twice as broad as long, convex above and behind, more concave anteriorly; posterior angles not projecting and covered with very short appressed pile, contrasting with the long and often dense erect pile on the basal ventral and basal dorsal surfaces of the same segment. Abdomen short, cylindrical, and laterally compressed, its surface minutely punctate; pile everywhere, even at the tip, and on the hypopygium, very short and appressed. Hypopygium armed with the usual short, slightly recurved teeth. In some specimens the red of the abdomen even on the dorsal surface is more or less suffused with black, especially near the middle of the different segments. Fore-wings reaching to the tip of the abdomen or even a little beyond. Venation very similar to that of *E. schmitti* (*vide* Fig. 1). Legs short, posterior pair not reaching the tip of the abdomen. Middle metatarsus a little more than half the length of the middle tibia. Denticles of claws vestigial.

At first sight the male of *E. opacithorax* is very similar to the male of *E. schmitti*, but comparison discloses a number of constant differences. Apart from its distinctly smaller size, the thorax and scutellum of the former species are more glabrous and therefore appear to be of a deeper black color. The pile is shorter on the abdomen and posterior portion of the petiole, the wings are distinctly smaller, less blackened, and have paler nervures.

The junior author has also taken the males of two other forms of Eciton at Austin, but hitherto only about the lights in the evening. One of these, taken October 29, agrees very closely with the description of *E.* (*Labidus*) *harrisi* Hald. The other, which was flying in considerable numbers August 1, is smaller and more reddish, with very pale wings. Professor Forel pronounces it to be *E. harrisi*, but as the color is not that of the type, it must be regarded as a variety. The heads of both forms, drawn to the same scale, are represented in Fig. 2, *a* and *d*. Besides the various species already mentioned we have recently taken at Austin the workers of *E. californicum* Mayr. and *E. pilosum* F. Sm. The latter species has not before been recorded from the United States. With the single exception of *E. carolinense*, all the species of Eciton known to occur north of Mexico have been found in Texas, and it is very probable that *E. carolinense* will be found in the eastern portion of the state. The species of the genus occurring north of Mexico may be tabulated as follows, according as they are known from the male or worker phase alone or from both :

Workers.	Males.
1. *Eciton cæcum* Latr.	*Labidus sayi* Hald.
2. *E. sumichrasti* Norton.	Unknown.
3. *E. schmitti* Emery.	*E. schmitti* Em.
4. *E. californicum* Mayr.	Unknown.
5. *E. opacithorax* Emery.	*E. opacithorax* Em.
6. *E. carolinense* Emery.	Unknown.
7. Unknown.	*L. harrisi* Hald.
8. Unknown.	*L. mexicanum* F. Sm.
9. Unknown.	*L. nigrescens* Cress.
10. Unknown.	*L. minus* Cress.
11. Unknown.	*E. spoliator* Forel.
12. Unknown.	*L. melshæmeri* Hald.
13. *E. pilosum* F. Sm.	Unknown.

The males of *E. schmitti*, after living in good condition in the artificial nest for a few days, began to die off, at first a few each day, then more, till by the evening of October 22, nine days after their capture, they were all dead. During this period, however, it was possible to make a few observations on their habits.

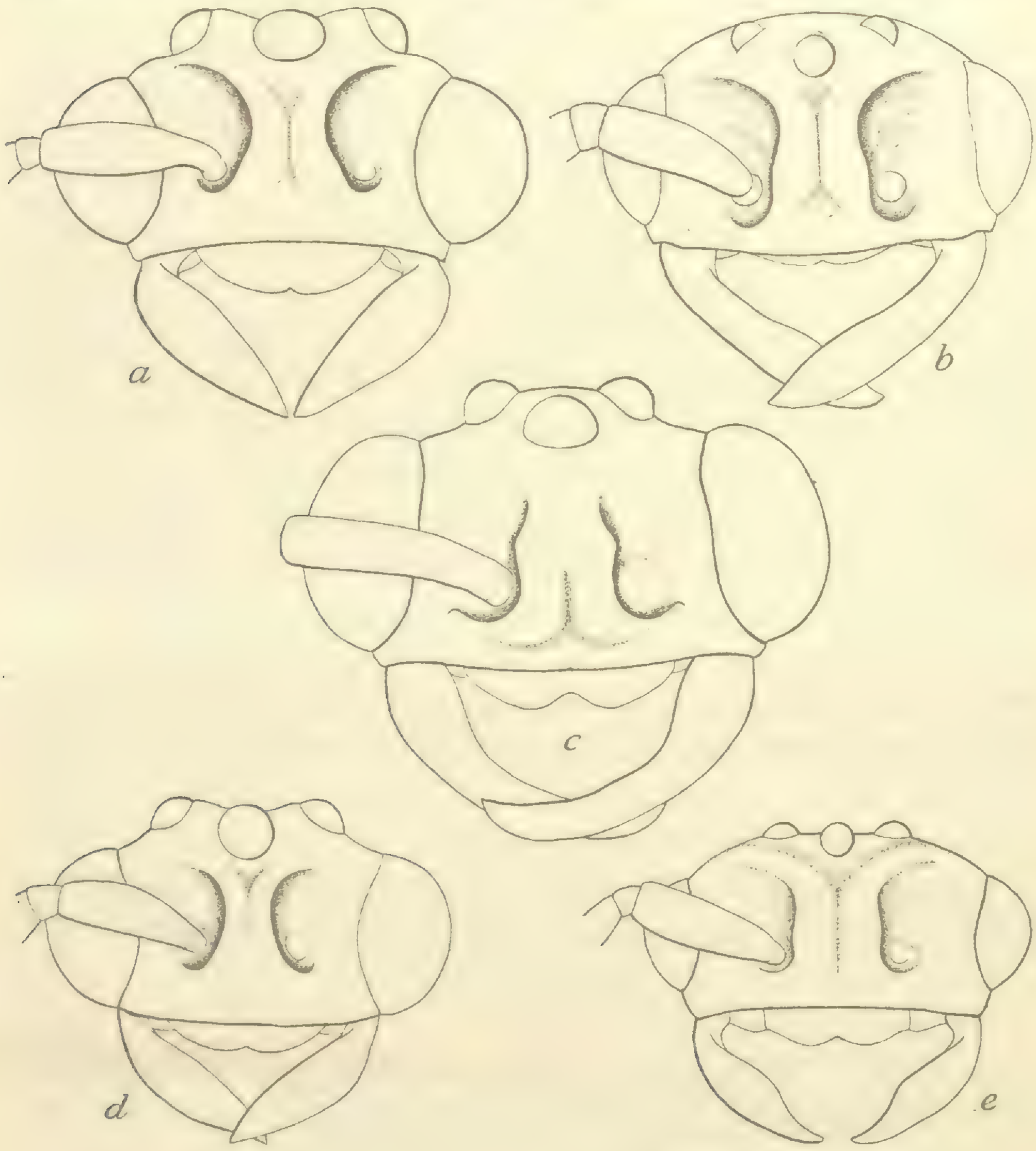


FIG. 2.— Heads of male ecitons. *a*, *E. harrisi*; *b*, *E. schmitti*; *c*, *E. cæcum*; *d*, *E. harrisi*, var.; *e*, *E. opacithorax*.

In his former paper the senior author recorded the fact that the odor of the workers of *E. schmitti*, like that of other species of the genus, is rank and disagreeable, whereas the **odor of the queens is mild and pleasant.**[1]

[1] The peculiar odor of Eciton workers was noticed by Sumichrast (Notes on the Habits of Certain Species of Mexican Hymenoptera, etc. Note 1, On the

It was interesting, therefore, to find that the males have the same pleasant odor as the females. We believe that this peculiar property acts as a powerful attraction to the workers, causing them to cling in great numbers to the bodies of the fertile sexes. Certainly no other ants with which we are familiar appear to be so fond of their queens and males. The workers seem never to tire of fondling and licking the latter. They lick even their large mandibles and the broad membranes of their wings, and when the males move about in the nest the workers ride on their backs and sides. Sometimes the males are loaded down so heavily with workers that they can neither walk nor fly. On such occasions they are often seen to relieve themselves of their too affectionate attendants by suddenly flirting their wings and tossing the workers to a distance. Even dead males are often fondled for hours. Although the males have beautifully developed strigils on their fore-tibiæ, they do not appear to use them while in the nest, probably because the continual grooming which they receive from the workers makes attention to their own persons unnecessary. In this respect the behavior of these male ants is in marked contrast with the behavior of the male Ponerinæ (*Pachycondyla harpax*, for example).

So far as could be observed the males made no use of their huge mandibles, structures which cannot fail to excite interest, because the mandibles of male ants are usually so small or even rudimental as compared with the mandibles of the workers and queens. The male ecitons were never seen to fight with one another or with the workers, nor did they take food of any form during their captivity. Since the female Eciton is wingless and sluggish, the mandibles of the males can hardly function as clasping organs. We are inclined, therefore, to regard them as secondary sexual characters belonging to the same category as the much larger mandibles of the male stag-beetles (Lucanidæ) or the cephalic and pronotal horns of many male chafers (Scarabæidæ). It is not improbable, however,

Habits of the Mexican Species of the Genus Eciton Latr., *Trans. Am. Ent. Soc.* (June, 1868), pp. 39–44), but erroneously attributed to the ants' living in rotten wood.

that when the mystery which still envelops the origin of the female Eciton and the time and place of her impregnation has been dispelled, the mandibles of the male may be found to have some as yet unsuspected function.

During the morning hours the ecitons remained very quiet, hanging in clusters in an angle formed by the soil and the glass of the jar, or between the glass and the earth of the Lubbock nest after being removed to the latter. The males, concealed beneath the mass of workers, were usually huddled together, with their heads hidden in holes in the earth and their abdomens and the tips of their wings projecting. They appeared to be sleeping. Between one and two o'clock in the afternoon the whole colony awoke. The males would begin to climb the glass sides of the jar in perfectly perpendicular paths, falling to the bottom from time to time but again persistently ascending. The workers would often file up the sides of the jar with the males walking at the same rate of speed in their ranks. The activity of the colony appeared to reach its height between five and seven o'clock, and then to subside as the night came on, when the colony again clustered with the males in its midst. Even a lamp kept in the room with the nest, if not too near it, failed to interrupt their slumbers. This striking rhythm of alternating activity and rest was observed on each of the nine days during which the males lived, and was continued by the workers alone for some weeks afterwards.

The numerous males of *E. schmitti* and *E. opacithorax* taken in the two nests above described showed relatively little variation in size and coloration. They were all equally fresh and active and had evidently all hatched but a short time before the nests were discovered. This induces us to add some remarks concerning the supposed dimorphism of the males of Eciton, if only for the purpose of corroborating Emery's statements on this subject. For the sake of bringing the matter clearly before the reader, we translate most of Emery's remarks.[1]

"In my memoir on the larvæ of ants[2] I omitted a discussion

[1] Nuovi Studi sul Genere Eciton, *loc. cit.*, pp. 4, 5.

[2] Intorno alle larve di alcune Formiche.

of the singular observations published by W. Müller,[1] which, as recorded, tend to show that the larvæ of Eciton are of two forms, one like those subsequently described by myself, the other furnished with setigerous tubercles, like the larvæ of the Ponerinæ. When, during the past autumn at the Munich meeting of German naturalists, I presented the results of my observations, Forel took exception to them, on the ground that the dimorphism observed by W. Müller in Eciton went to prove that the cutaneous tubercles could not be peculiar to the larvæ of the Ponerinæ. I was thus compelled to examine Müller's observations, for the purpose of ascertaining whether or not Forel's conclusion and those of the author himself were legitimate.

"Among many thousand typical larvæ of Eciton, Müller observed a very few much smaller larvæ, covered with tubercles and some dark-colored cocoons containing similar larvæ and pupæ and differing from those of the ecitons. The tuberculate larvæ were of different sizes and forms, and most of the dark-colored cocoons woven by these larvæ measured 8 mm., but some of them only 6 mm., in length. As it was not known at that time that the larvæ of the Ponerinæ are of this structure, he could not suppose that he was dealing with larvæ stolen from the nest of other ants. Müller and Forel, who examined the material collected, thought there was an evident connection between the two observations to be discussed, a fallacious connection which, nevertheless, as an element of suggestion, has dominated the whole thought of these authors.

"In the midst of the mass of worker ecitons Müller found a deälated and damaged specimen of the insect then known as *Labidus burchelli*, the male of the Eciton which was the subject of his observations. On examining a pupa taken from one of the dark-colored cocoons and hence derived from a tuberculate larva, Forel observed that, whereas the form of the head and thorax was that of a worker ant, the tip of the abdomen presented appendages, which, though poorly preserved in the specimen studied, recalled by their position and configuration

[1] Beobachtungen an Wanderameisen (*Eciton hamatum*) in *Kosmos*, 10. Jahrg., Bd. xviii (1886), pp. 81–93.

the copulatory appendages of the male sex. This pupa must, therefore, be a male, though very different from the Labidus, as shown in the figures which I repróduce in the plate accompanying this memoir (Fig. 30, *a*, *b*, *c*). Believing the determination of the sex to be correct and desiring an explanation of the facts, the specimen was supposed to be a heteromorphic male of Eciton, and the tuberculate larvæ were therefore regarded as male larvæ, the smooth ones as belonging to ants of the female sex. Thus arose the strange doctrine of the dimorphism of the males in the genus Eciton. The new heteromorphic male was, from analogy with the termites, designated as a supplementary male."

From an examination of W. Müller's figures, Emery concludes that the pupa which gave rise to the above view was a normal worker pupa of some ponerine ant, presumably a species of Pachycondyla which had been appropriated by the ecitons. That Emery has drawn the correct inference from Müller's data is very clear from the following observations made on *E. schmitti* during the past spring. These observations are transcribed from the notebook of the senior author.

May 25 we came upon a colony of *E. schmitti* under a large flat stone. The ants had dug their galleries to a depth of several inches in the moist black soil and had literally packed them with larvæ and pupæ. The latter were more abundant and were at once seen to be the slender, naked worker pupæ of the Eciton. The relatively small number of larvæ were nearly mature and closely resembled the figures of Eciton larvæ published by Emery.[1] There were, however, many naked pupæ and larvæ of very different shapes and sizes. Some of the former had wing-cases, and for a few days the senior author lived in the pleasant anticipation of being able to hatch the male ecitons, since much of the nest had been captured and placed in a large glass jar. The ecitons at once set to work and collected the slender larvæ and pupæ and then turned their attention to the others, which were finally brought together in the same place. Some of the winged pupæ and

[1] Intorno alle Larve di Alcune Formiche, *Mem. della Accad. delle Scienze dell' Istituto di Bologna*, 7 maggio, 1899, 2 tav.

the obese larvæ from which they were evidently derived were examined more carefully, and it was found that many of them were queen larvæ and pupæ of some one of three species of Pheidole whose nests had been noticed a short distance from the Eciton nest. Other larvæ and pupæ appeared to belong to another common ant, *Solenopsis geminata*. There could be no doubt that the ecitons had stolen all these myrmicine progeny, which they proceeded to devour a few days later till all had disappeared.

That this habit of pillaging the nests of other ants is shared also by the tropical ecitons is shown by the following observation recorded by Sumichrast[1]: "It is probable that the Eciton attacks the larvæ and pupæ of other ants to make them serve as food for the nourishment of their own larvæ or for sustaining themselves. I surprised one day, in the first hours of a somber and rainy morning, a considerable assemblage of *tepeguas* (No. 36), fastened one upon another like a swarm of bees, and entirely still. Having dispersed them, I perceived in the place which they covered with their bodies a quantity of little white larvæ, brought away, doubtless, from the nests of some Myrmicidæ. At another time I witnessed the pillage of a nursery of other ants by a quite numerous band of workers minores of No. 68; alarmed by the reprisals which I made on their account, they took to flight, some of them carrying between their mandibles as many as three larvæ at once."[2]

The habit of seizing the larvæ and pupæ of other ants and of storing them in their nests for several days till required for food is only a special phase of a more general habit of the ecitons and probably also of some other ants, for the ecitons do the same with the other portable insect booty which they

[1] *Loc. cit.*, p. 42.

[2] Recently at Querétaro in Mexico the senior author surprised a troop of *Eciton crassicorne* Sm. pillaging a large nest of the agricultural ant (*Pogonomyrmex barbatus*). The temporary nest of this powerful Eciton was found under a large stone only a few yards away. It contained a number of dead agriculturals. At Cuernavaca the same species of Eciton was seen pillaging some small Pheidole nests and dragging away carabid beetles from under the stones.

capture on their marauding expeditions. When they migrate to a new nest they carry this booty with them, as shown by the following observation made in the city of Galveston during the past June. A large colony of *E. schmitti*, which had been living under the front doorstep of the house in which the senior author was stopping, decided to change their quarters. In the early twilight the entire colony moved out in regular file through the garden and entered a new nest which was being dug only a few yards from the old one about the roots of some violets. While carefully scrutinizing the file of ants for the purpose of detecting any ecitophiles which might be marching with them, the ecitons were seen to carry considerable numbers of dead carabid beetles (small species of Harpalus and Pterostichus). These evidently represented their store of food for the time being. Since this observation was made, the senior author has had frequent opportunity to feed the ecitons in artificial nests with termites and the larvæ of ants (Camponotus and Pachycondyla!). In all cases many of these larvæ and termites were carried about or stored in one corner of the nest for several days before they were eaten.

Postscript.

The first female Eciton known to have been taken in the United States was discovered by Rev. P. Jerome Schmitt in April, 1894, on the grounds of St. Mary's College, Belmont, Gaston County, N. C. The insect was found under the bark of a tree and concealed under a large mass of workers half rigid with the cold. Eighty to one hundred specimens of an ecitophilous beetle (*Ecitonusa schmitti* Wasm.) were found scattered through the cluster of workers. The latter were identified by Wasmann and Emery as belonging to *E. opacithorax* Emery. The description of the female has been delayed till the present time, as Rev. Mr. Schmitt happened to be more interested in other fields of entomology. At our request he has most generously sent us the insect for examination and description, and has also permitted us to use the accompanying cut, prepared for him some years ago under the direction of Messrs. Schwarz and

Pergande. Through this kindness Rev. Mr. Schmitt has enabled us to complete our description of the sexual forms of *E. opacithorax*, the male of which is described above. Comparison of the female of this species with the female of *E. schmitti* shows such striking similarity that unless the specimens had been taken with workers of two very different species, one would scarcely regard them as specifically distinct. The following slight differences can be noticed: The female *E. opacithorax* has the head somewhat more shining, with smaller punctures, which are not confluent as in *E. schmitti*; the eyes are smaller, the hairs on the dorso-lateral portions of the head are shorter, the occiput is distinctly less depressed in the middle line, and the pronotum is somewhat rounder and more convex above. The thorax is less confluently punctate, more evenly hairy, and the petiole is less concave in the middle. The size and color of the two species are very nearly identical; even the large dark blotches on either side of the metanotum are present in *E. opacithorax*.

FIG. 3.— *Eciton opacithorax* Emery.

If we may be permitted to generalize from the study of the two species of Eciton, of which we have seen all three phases, it may be said that the fertile forms of the different species of this genus are even more difficult to distinguish from one another than the workers. For this reason, and also on account of the much greater rarity of the males and females, myrmecologists will probably continue to regard the worker ecitons as of greater taxonomic importance.

UNIVERSITY OF TEXAS, AUSTIN, TEXAS, Nov. 15, 1900.

THE MORPHOLOGY OF THE HINGE TEETH OF BIVALVES.

WILLIAM H. DALL.

THE most notable step in advance for the study of bivalve mollusks which has been made for many years is due to the researches of the late F. Bernard, which are included in half a dozen papers, of which the earliest appeared in 1895.

Ever since the time of Schumacher and Lamarck, in the early years of the century, the interlocking projections of the dorsal margins of the valves of pelecypods have been recognized, under the name of hinge teeth, as affording characters of the highest value in systematic classification of the subdivisions of this group. All works treating of these animals have utilized the more or less obvious features of the adult hinge teeth in framing diagnoses of families and genera. Systematists contented themselves, however, with noting the number, position, and division of the teeth into so-called "cardinals" and "laterals" and ignored the fact that large groups have teeth of special types, which can hardly be closely homologized with the teeth characteristic of several other groups. This method of treating the teeth was unquestioned for more than half a century and became so fixed in the minds of systematists that modern efforts to suggest a new point of view have up to the present time been almost futile. Steinmann, in his *Lehrbuch der Paleontologie*, Fischer, in his *Manual* (1887), and especially Neumayr, in his *Morphologie Bivalven Schlosses* (1883), emphasized the necessity of distinguishing between certain fundamental classes or types of hinge teeth, and to Steinmann we owe the suggestion of a formula for indicating in brief form and almost graphic manner the number and relations of the teeth on any given hinge. The writer, in 1889, and Neumayr, in a posthumous paper issued in 1891, applied these principles to the general classification of bivalves, necessarily

in a tentative manner, but further advance, or even the confirmation of steps already taken, could be made only on the basis of observed facts of development in concrete cases. Munier-Chalmas (1895) propounded certain theories of prototypic hinges, but in the absence of published observations these attracted slight attention. In the same year the writer elaborated his previous thesis, insisting on the modifications due to dynamic causes acting directly on the hinge, on the origin of hinge teeth from initiative due to external sculpture in the dorsal region, and on the duplex nature of the so-called ligament, which many years before had been recognized by Récluz, whose observations fell on sterile soil. The existence in many nepionic bivalves of a primitive hinge, since named the provinculum, was also pointed out. Almost simultaneously the first of Bernard's papers appeared, for the first time furnishing facts in relation to the development of the hinge teeth in a comparative series of different genera ; and thenceforward, until the time of his premature decease, he continued to bring together invaluable data in the same line, covering a large number of genera and opening the way to a field of research of extraordinary promise, throwing an entirely new light on the development of hinge structure and making a permanent breach in the barriers of a conservatism which had so long retarded the appreciation of efforts for a more scientific consideration of the facts of hinge structure. As in all first attempts, the shackles of outgrown methods were not wholly discarded, and much more study is required before a final system can be hoped for, but so much has been done that it is no longer possible for the former inertia to prevail. Several papers bearing on this subject have recently appeared. One of them, by W. von Vest,[1] can be briefly dismissed, as it contributes nothing new in the way of facts and is chiefly devoted to the introduction of a host of new technical German terms, which in turn are reduced to symbols, which when formulated

[1] Ueber die Bildung und Entwicklung des Bivalven-Schlosses, followed by Entwurf einer Einteilung der lebender Bivalven nach dem Schlossbau, *Verh. des Siebenburgischen Vereins für Naturw. zu Hermannstadt*, Bd. xlviii (1899), pp. 25–150, Pls. I–III.

comprise five or six lines of difficultly intelligible letters and figures, requiring three or four times as much more space devoted to "Erklärung der Formel," and, when all is said and done, hinder rather than help. How long will it be before it is universally understood that symbolization which has not the merit of brevity is not only a foolish waste of ingenuity and time but is absolutely without any chance of acceptation?

In this connection it may be noted that Munier-Chalmas proposed a system of notation for the hinge of bivalves which erred not only by involving much purely hypothetical assumption but also by inordinate length. A better was proposed by Bernard, of which some modification is suggested by Dr. Fritz Noetling[1] in an interesting and suggestive paper which has lately reached us. Bernard began work on the teleodont forms (Heterodonta of Neumayr) and under the influence of Munier-Chalmas. As many of the Teleodesmacea have comparable hinges, it was natural that Bernard should suppose that all hinges were comparable and that the formula he proposed should be based on the assumption that from the mere position on the hinge plate the homologies of the individual teeth could be taken for granted, which we believe to be a very mistaken idea. Bernard in his later work realized that error, but unfortunately was not spared to consider the revision of his symbols. As a matter of fact even in the Teleodesmacea Bernard showed before his death that several distinct systems of tooth development can be recognized which cannot be interchangeably homologized. Much more is it impracticable to homologize teeth of such groups as the Prionodesmacea and Teleodesmacea. In groups where it is practicable, — to be determined by observation and not by theory, — Bernard's system will doubtless, with some modification, continue to be used. It is, however, very liable to lead the student unacquainted with its pitfalls into an unprofitable wilderness of theory, when, for the present, facts, and again facts, are imperatively demanded. If we eliminate theory, it still remains important that there should be some symbolical way of presenting the facts to the eye without

[1] Notes on the Morphology of the Pelecypoda, *Palæontologia Indica*, N.S., vol. i (1899), pp. 1–43, No. 2. Calcutta.

extended verbal description, and for this we must fall back on some modification of Steinmann's system, which for clearness and brevity can hardly be excelled. It is essential also that the student should not forget that the teeth are not, so to speak, individualities or specific organs, no matter how true they, in the main, are bred from generation to generation. Apart from their genetic origin as the selected results of the dynamic influence of external sculpture on limited areas of the shell (this sculpture itself being a selected consequence of the dynamic influence of the irregularities of the edge of the mantle upon the shell it secretes), the teeth are essentially prominences of a structure of homogeneous material modified by strains and impacts, and an excess or deficiency in the dynamics of the hinge margin in any individual will directly affect the hinge. The proof of this is most obvious in the differences of the lateral lamellæ which will be found in examining a large series from different localities of such a type as Tellina, for instance.

One important result of Bernard's researches was to show that cardinal and lateral are the disunited segments of an originally continuous lamina, and hence of genetically identical origin in certain teleodonts. In others the cardinals and laterals probably are distinct in origin (Tellina), though these developments so converge that in the adults they would be homologized by any student. The dynamic influence of the ligament when internal is very great and differs at different stages of growth in the same individual. In general it prevents the formation of the "hook," from which cardinal teeth are developed, on the laminæ at the posterior end of the shell, but in some Leptonacea and Crassinella, where the internal resilium is nearly central, prominences which are genetically identical with the so-called cardinals are formed also behind the beaks. The inclination of the teeth to a perpendicular from the beaks is a function of the torsion of the umbonal extremity of the valve and may differ strongly in otherwise closely related species. The cyclodont type of hinge largely results from such torsion. This inclination therefore should not be discussed as if it was an essential character of the teeth in themselves.

For those who may be interested to look into this subject it will be useful to explain the formulæ proposed by Bernard and Steinmann, with their subsequent modifications.

In Bernard's scheme the teeth are numerals, — those of the right valve with odd, and of the left valve with even numerals; the cardinals have Arabic, the laterals Roman numerals. The character of the teeth is further indicated by capital letters, and their origin by lower case italic letters corresponding to the primitive lamina from which they are supposed to have been detached in the course of development. Bernard begins with the median cardinal and numbers both ways. In most pelecypods the cardinals are all anterior, though the laterals are either anterior or posterior. He begins with the ventral laterals and numbers upwards. One of the interesting points made by Noetling is that the ventral lateral laminæ are sometimes the younger, and therefore the homologies which may be inferred from the numeration beginning below are liable to be disturbed, whereas if the numeration of the laterals began from above, the dorsal laminæ being, as he contends, the older, this source of error would be eliminated.

In our opinion liability to error is inherent in the system which attempts to combine theoretical assumptions as to age and origin with a numerical indication of facts. Laterals may undoubtedly be added above as well as below in the course of growth, for the dorsal margin of the hinge plate is added to as well as the ventral; the hinge, when the ligament is opisthodetic, or posterior to the beaks of the valves, increases at both edges as long as the shell continues to grow.

Bernard indicates the sockets by a colon and uses the letter L between vertical bars to indicate the place of the ligament. The portion of the ligament which is internal is (so far as known) always the resilium, so it would be better to use R as a symbol, the letter L being already appropriated to symbolize the lateral laminæ. Vertical bars are also used to separate the anterior laterals from the cardinal series, though, as the index letter L or C is already in use as an indicator, the bars do not seem to be needed. If we take as an example the case of a bivalve having three cardinal teeth and two anterior and

posterior laterals in each valve, Bernard's formula would be as follows, — the anterior end of the hinge being at the left end of the formula.

Right valve	L A I : III :	Ca 3a : 1 : 3p :	R	L P I : III :
Left valve	L A II : IV	Ca : 2a : 2p : 4p.	R	L P : II : IV

The Steinmann formula for the same shell is :

$$\frac{\text{R l o l o} \cdot \text{1 o 1 o 1 o r l o l o}}{\text{L o l o l} \cdot \text{o 1 o 1 o 1 r o l o l}}$$

Ordinarily this formula is written in the opposite direction, bringing the left valve above the line, but I have reversed it here to make the formulæ more comparable. In the Steinmann formula we put l for a lateral and 1 for a cardinal ; o for a socket, and a period to set off the anterior laterals from the cardinals. In this formula nothing is left to theory : the figures symbolize exactly the number and relative position of the parts of the hinge and a diagram could hardly do it better; of course it is capable of enlargement : for instance, bifid teeth may be symbolized by a fraction ½, instead of a single digit ; the amorphous irregularities which occur on such a hinge as that of *Venus mercenaria* may be symbolized by an X, and the soldering of adjacent teeth by the insertion between their symbols of a + sign. All the facts of the hinge of an adult shell can be indicated by this formula. It is only when the facts of the development of any particular hinge have been ascertained that we can use the Bernard formula with equal confidence and accuracy.

The initiation of denticulations on the hinge plate by external sculpture, as pointed out by Neumayr, is illustrated in many of the curious Paleozoic bivalves which he called Paleoconchs. These forms, though not in themselves the oldest known pelecypods, or prototypes, doubtless illustrate the method by which in prototypic forms the organs in question were evolved. Moreover, in the living Mytilidæ, especially the more minute and deep-water forms, the same process in various stages can be directly observed. In some of them, as, for instance, Dacrydium, the development of hinge teeth stops

with the completion of the crenulations which in many other pelecypods form only the nepionic hinge or provinculum. The provinculum is common to all the Prionodesmacea, bivalves which include Neumayr's Taxodonta (Arca, Nucula, etc.) and Dysodonta (Mytilus), and other ancient types (Unio, Perna, etc.). A few of the Teleodesmacea (Heterodonta and Desmodonta of Neumayr) also retain traces of it. The marvelous thing in the development of the hinge is that in the vast majority of hinges, including such primitive types as Nucula, the hinge does not go on developing from the provinculum, but the latter stops short and, as it were, after an interval, a wholly new set of teeth, taxodont or other, begins to develop. In the taxodonts there is a multiplication of similar teeth, often more or less ∧-shaped, separated by a gap from the most adjacent of the provincular teeth, even when closely similar to them. The explanation of this discontinuity in development is the most interesting question to be solved in connection with the pelecypod hinge. In the Teleodesmacea instead of a multiplication of similar teeth we have a few, usually with one limb, of the ∧ disproportionately elongated. The apex of the ∧ being adjacent to the umbo, the proximal portions develop into the so-called cardinals on the anterior side of the ligament. Only in forms (Crassinella) having a very symmetrical development is there any indication of a cardinal behind the ligament. The distal end of the long limb of the ∧, usually the upper or outer limb, develops into a so-called lateral tooth. This process is characteristic of the forms (Venus, Cyrena, Mactra, etc.) included by Bernard in his cyrenoid type of heterodonts. In others the connection between the processes called cardinals and laterals is practically wanting; the laterals arise separately from the first, as far as observation can determine at present. These are types having the hinge much elongated and the laterals distant (Tellina), or absent (Macoma), or in which the teeth are what I have called cyclodont (Cardium, Isocardia), arising from below the hinge margin and practically without a hinge plate. Most of these were included by Bernard in his lucinoid type of heterodonts. There is nothing to deter us from believing that all these types are fundamentally

of common origin ; the few-toothed ledas approach the heterodont type, sometimes very closely ; but the divergencies must have begun very early in the history of pelecypods and the differentiation is now very marked. It is earnestly to be hoped that such researches as those of Bernard will be continued until light is thrown on all the various problems for which we now know no suggestion of a solution.

UNITED STATES NATIONAL MUSEUM.

THE PHARYNGO-ŒSOPHAGEAL LUNG OF DESMOGNATHUS.

HARRIS H. WILDER.

Since the discovery of lungless salamanders in 1894, numerous investigators have endeavored to ascertain the method of respiration in these forms. Camerano (1894), after a series of physiological experiments upon *Spelerpes fuscus*, came to the conclusion that integumental respiration was no better developed than in other Amphibia, and that the respiration must be mainly bucco-pharyngeal. Directly along this line Maurer (1897) showed that in lungless forms the pharyngeal capillaries pass beyond the corium and actually invade the epidermis, a condition unique among vertebrates. Hopkins (1896) supplied an interesting point of negative evidence, that in lungless salamanders the pulmonary vein is entirely wanting, and that correspondingly the left atrium is reduced to a rudiment. This view was slightly modified by Bruner (1900), who showed that what Hopkins had taken for the *septum atriorum* was really a valve and that a proper septum did not exist, hence the single atrium of lungless forms is probably due to a confluence of the original two.

A careful study of the blood vessels of both lunged and lungless salamanders was conducted by Bethge (1897), with the result that he located in the latter (*Spelerpes fuscus*) a pharyngeal plexus of capillaries, the vessels of which seemed swollen at irregular intervals. Miss Woldt (1897) found a pulmonary artery in Plethodon, supplying both œsophagus and skin.

Thus far, however, the investigation seems to have centered about the organs of circulation, and, consequently, a curious set of facts along a different line has been entirely overlooked. Although these have been met with and described by various investigators, no conclusions have been drawn from them.

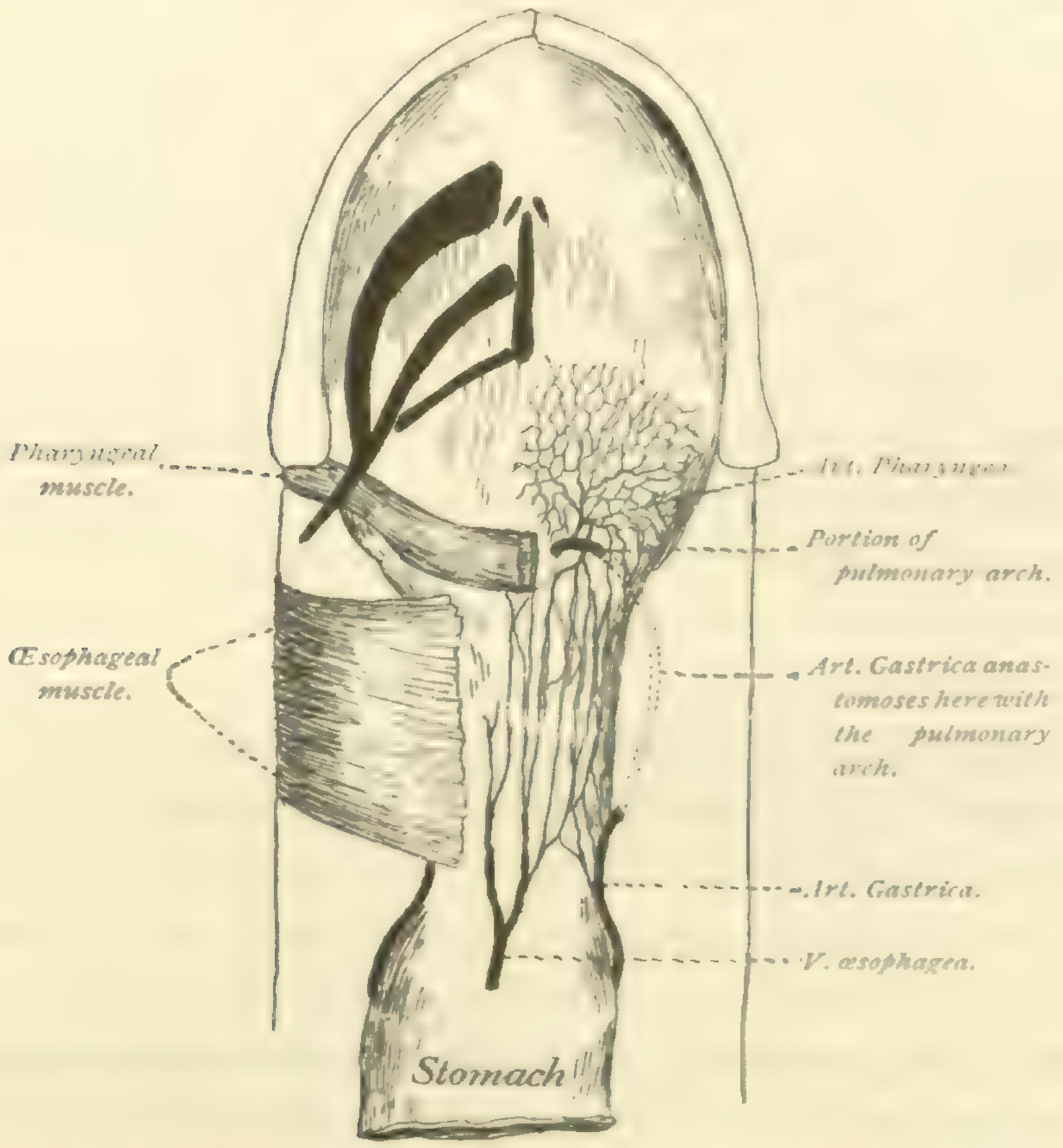
The first of these is the obvious fact, to which my attention was first directed by Dr. H. S. Pratt, that lungless forms breathe in the same way as do other salamanders; that is, they indulge in rhythmic respiratory movements during which the throat fluctuates in and out with considerable rapidity. A second closely related fact is that recorded by Bruner (1896), that, in common with salamanders with lungs, the several species of lungless forms investigated possess a muscular apparatus for opening and closing the anterior nares. Although in lunged forms this apparatus is directly connected with the respiratory act, Bruner, influenced by the general opinion that lungless forms could not really breathe, explained the presence of this apparatus in such genera as Desmognathus and Spelerpes as solely a protection against water. The third fact, which has remained entirely unexplained until now, is the presence in lungless salamanders of well-developed respiratory muscles identical with those possessed by other Urodeles and inserted into the walls of the pharynx and œsophagus (Wilder, 1896).

The meaning of these incongruous and apparently unrelated facts has at last been made clear through the careful investigations of one of my assistants, Miss Anne Ide Barrows, whose preliminary report on the subject has just appeared in the *Anatomischer Anzeiger* (Bd. XVIII, Nos. 18, 19). Miss Barrows has just concluded a long and exhaustive study of the entire circulatory system of *Desmognathus fusca* and has succeeded in demonstrating that *not only the pharynx*, as shown by Bethge in Spelerpes, *but also the entire œsophagus, is supplied with a dense capillary plexus, the vascular area of which is of sufficient extent to transform the entire pharyngo-œsophageal region into a functional lung of at least as great respiratory power as that of the paired lungs of normal salamanders.* The plexus is formed mainly by four arteries, two external maxillaries on the dorsal, and two pharyngeal on the ventral side. Posteriorly a few branches of the gastric artery contribute to the formation of the plexus.

It is worthy of note that a large part of the plexus is formed by arteries from the fourth or respiratory arch, and that much

of the aërated blood is not returned directly to the heart but enters the hepatic portal system through a pair of œsophageal veins.

The demonstration of this respiratory organ puts the necessary meaning into the three facts enumerated above, for since there is a functional lung there must be respiratory movements performed by respiratory muscles, and thus the true function, both of the small muscles about the anterior



Ventral aspect of pharynx and œsophagus of *Desmognathus fusca*, showing the plexus of blood vessels. The background of this figure was drawn by the author, based upon one published in 1894. The blood vessels were added by Miss Barrows.

nares and the large internal set, becomes evident. Concerning these latter, the respiratory movements induced by them are of two kinds: an act of inspiration which expands the pharyngo-œsophageal region and an act of expiration which contracts it again. The muscles employed in inspiration are evidently those which arise from various dorsal and lateral points and become inserted along the sides of the pharynx and œsophagus, called by me the dorso-laryngeus, scapulo-pharyngeus, and

œsophageal muscle. These by their contraction draw apart the walls of the alimentary canal in this region, and the external air rushes in through the nostrils to fill the vacuum thus formed. In my previous paper, not having the present point of view, I said little about the muscles used in expiration, but it is now obvious that the well-developed muscular layer which surrounds the pharynx in some of the species, and which I have figured in Fig. 2 of the article referred to under the name of pharyngeal muscular sheet, must have that function. It is also probable that in some species the *digastricus pharyngis* becomes a powerful expiratory muscle.

Summarizing the results thus far obtained, we may state the following: *Desmognathus fusca* breathes mainly by means of a definitely localized portion of the anterior part of the alimentary canal, which may be known as the *pharyngo-œsophageal lung. The walls of this organ are richly supplied with blood from a capillary plexus which is irregularly reticular in its pharyngeal portion, and in its œsophageal portion consists mainly of very numerous longitudinal vessels which run parallel with the mucous folds. Rhythmic inspiratory and expiratory movements of this organ are caused by two sets of muscles, the one dilating and the other contracting the lumen.*

These motions are accompanied and assisted by respiratory movements of the floor of the mouth, as in other salamanders. The mouth is normally closed during respiration, and the nostrils are used for the passage of air. The anterior nares are equipped with a regulating apparatus, as in other salamanders, and for the same purpose.

Although the above summary rests upon recent investigation upon a single species, it is probable that a similar organ exists, with some slight modifications, in the other lungless salamanders. The bibliography referred to here merely by the author's name is given in full in Bruner's latest article on the subject in the *Journal of Morphology*, February, 1900, to which the reader is referred.

SMITH COLLEGE, Nov. 16, 1900.

NOTES ON THE HABITS OF CAMBARUS IMMUNIS HAGEN.

J. ARTHUR HARRIS.

In the present notes I intend to give only a few observations made on the habits of one of our common crawfishes, *Cambarus immunis* Hagen. The material which I have examined seems quite variable, and a part of it would probably fall under Faxon's variety, *spinirostris*. It does not embrace all the data I have at hand, and as more is being collected as rapidly as opportunities for field work are presented, I hope in the near future to give a much more complete account of the habits of this and other forms. These few points are presented here simply because they seem to throw some light upon one or two questions concerning the habits of the crawfish, a field which I feel sure is deserving of careful study.

C. immunis is decidedly a mud-loving species. Faxon[1] says: "Mr. H. G. Hubbard has found it in muddy pools and ditches connected with the Detroit River, Michigan. According to Mr. Hubbard, it does not form burrows but conceals itself among weeds." Herrick,[2] in his description of *C. signifer* [= *C. immunis*], says: "Found by hundreds in a shallow pool known as Grass Lake in Richfield, Hen. County." Forbes[3] says: "This is the commonest species of central Illinois. It is especially frequent in the muddy ponds of the prairies, whence it may be drawn by the hundred with a small seine." Hay[4] says: "This species is a mud-lover, being found in great numbers in muddy

[1] Faxon, Walter. A Revision of the Astacidæ, *Mem. Mus. Comp. Zool. Harvard College*, vol. x (1885), No. 4.

[2] Herrick, C. L. Papers on the Crustacea of the Fresh Waters of Minnesota, *Tenth Rept. on the Geol. of Minn.*, 1882.

[3] Forbes, S. A. List of Illinois Crustacea, with Descriptions of New Species, *Bull. Ill. State Lab. of Nat. Hist.*, vol. i, No. 1.

[4] Hay, W. P. The Crawfishes of the State of Indiana. *Twentieth Ann. Rept. Ind. Geol. Survey*, 1896.

ponds in the early spring. I have always found them in the greatest abundance in ponds which became perfectly dry during the summer months, but where the crawfish go during this time I have never been able to ascertain. Doubtless great numbers of them are eaten by birds and other animals, and great numbers of them perish; yet by the next spring they are as abundant as ever and of about the same size."

C. immunis is our most common species in Douglas County, Kansas, and is found in almost precisely the same habitat as reported above for Illinois, Indiana, Michigan, and Minnesota. Roadside ditches and ponds in pastures are favorite places. In this county we have ponds in an old river bed which contain immense numbers of this species. These ponds are six to eighteen inches deep, depending upon the dryness of the season. They are very muddy and have usually in the shallower parts, which are apt to become dry during the summer, a rank growth of Polygonum and plants of like habit. From such a pond I took, one day in October, 1898, in company with Mr. C. D. Bunker and another collector, about fifteen hundred specimens, of which only a very few were less than two and one-half inches in length. There were not more than a half dozen small specimens in the whole lot; in other ponds, however, I have made collections which showed almost all stages of development. In many of the ponds *C. immunis* seems to be the only species, but in others we find also *C. gracilis* Bundy and *C. virilis* Hagen (?), but these do not occur in nearly so great numbers as does *C. immunis*.

According to my observations, *C. immunis* is a burrowing and, at least to a certain extent, a chimney-building species. Burrowing, however, appears to be only resorted to when there is danger of the drying up of the ponds or on the approach of winter. Lack of opportunity for examining the ponds in all different conditions without doubt accounts for the failure of Hubbard[1] or Hay[2] to observe the burrowing habit of this species. Hay's suggestion of crawfish perishing upon the drying up of the ponds seems to me to be largely ungrounded, since I have never found any considerable numbers of dead ones in

[1] Faxon, W. *Loc. cit.* [2] Hay, W. P. *Loc. cit.*

many places which I have visited in all stages of drying up. Possibly birds may eat a few, but probably these are mostly water birds which could easily get the crawfish in the shallow water at any time.

In early September, 1900, I visited a pond, which earlier in the season had many crawfish in it, and found there were many burrows around the edge and but few animals in the pond. Upon digging out one of these burrows, which had a chimney about four inches high and five inches in diameter at the base, I found a large first-form male and a somewhat smaller female. The burrow was about fifteen inches deep and about one and one-half inches in diameter; at the bottom it was expanded into a cistern-shaped chamber about three and one-half or four inches in diameter. It appeared that the burrow had been carefully sealed by the animals. Some time later I examined the pond when it was almost dry and found no crawfish, but plenty of chimneys in various stages of disintegration. At about the same time in another pond, which contained more water, the crawfish were abundant. About the middle of October, 1900, I examined the burrows of *C. immunis* around the first pond mentioned above. Some of the burrows had chimneys, others were simply open at the top; probably those which had no towers were old burrows whose chimneys had been disintegrated by the weather. The chimneys were of different forms, some being almost regular, while it was evident that others were formed simply by the mud being thrown out of the burrow. Sometimes the mud appears to be just thrown out on one side, then, after a considerable amount of material has accumulated, the remainder is thrown out wherever convenient, forming an irregularly circular mound one to three inches high and six to nine inches across, or sometimes a long ridge with the shaft in the middle, the material here being thrown out in both directions. Sometimes the work is stopped before enough mud has been removed to make it inconvenient to throw it all to one side; thus forming a crescent-shaped pile. The highest chimneys noticed were about five inches high and three inches in diameter at the top. These were sometimes much inclined from the perpendicular. On the

whole, I think that, for this species at least, the theory of Tarr[1] and Shufeldt,[2] that the chimney is simply the deposition of the material brought up from the burrow, is correct. The mud is brought up in very soft condition, and I think that even if the burrow were made in the sloping side of a ditch there would be little danger of the pellets rolling down, as suggested by Abbott ;[3] in fact I have examined several burrows on the sides of ditches, presumably in the same kind of position as those examined by Mr. Abbott, and I have not been able to convince myself that anything except the easiest method of disposing of material from the burrows could have prompted the animal to build chimney-like structures. The quantity of material brought up is very considerable, amounting in some cases to nearly two hundred cubic inches.

As suggested above, the accidental sealing of the burrows would seem to be impossible. I believe that I found the "dumps" in enough different stages of construction to warrant the conclusion that the opening through the tower is left open until the last, when it is closed by stopping with mud brought from below. The opening is thus filled solidly from the top, or near the top, to almost the level of the ground, where the shaft has a concave hemispherical end, which is not so smooth as Shufeldt's[4] description of the burrow of *C. diogenes* would seem to indicate. And I cannot agree with him that the animal might have used the lateral tail fins in finishing this off, since I have never seen impressions in the mud which would indicate such a method, while there are many marks which would indicate that the animal had run the ends of the chelæ into the soft mud. In at least one case which I examined, the burrows had been filled to somewhat below the surface of the ground with clay so tightly packed that it would seem impossible that it might have fallen in by accident. The shaft usually goes straight down, but in some

[1] Tarr, Ralph. Habits of Burrowing Crayfish in the United States, *Nature*, vol. xxx (1884), p. 127.

[2] Shufeldt, R. W. *Chapters on the Natural History of the United States.* New York, 1897.

[3] Abbott, C. C. Are the Chimneys of Burrowing Crayfish Designed? *Amer. Nat.*, vol. xviii (1884), p. 1157.

[4] Shufeldt, R. W. *Loc. cit.*

cases may be somewhat sinuous. They are quite deep, one being followed down for four feet without reaching the end. I am not able to convince myself that there was a ledge upon which the animal could rest, as stated by Hubbard[1] for *C. argillicola*, although in some cases the burrow seemed to be expanded in a way which might serve for this purpose. In one case examined quite early in the fall, the main shaft went straight down; at a distance of about six inches from the surface a branch went off at almost right angles and ended somewhat higher than it originated about eighteen inches from its connection with the main shaft. It might seem that the animals do not like to stay down in the bottom of the burrow very long, at least early in the fall, since when a small excavation extending somewhat below the water mark was made in one of the burrows the animal came to the top and darted back two or three times when I attempted to catch him, which I finally succeeded in doing. The burrow was left for a few minutes and when again examined a medium-sized female had crawled out of the water and was standing on the almost perpendicular side of the excavation.

Hay's[2] theory, that the burrows of *C. diogenes* are made to escape the dry months of summer, seems undoubtedly the explanation for the summer burrowing of this species, while of course the purpose of burrows made or enlarged upon the approach of winter is evident. It is certain that the burrows are not adopted as retreats, while the eggs are being hatched, for I have taken the females in the open ponds in the fall, apparently soon after the eggs were laid, and they come out early in the spring — about March 20 — to complete the process of hatching the eggs.

UNIVERSITY OF KANSAS,
Nov. 10, 1900.

[1] Faxon, Walter. Descriptions of New Species of Cambarus, *Proc. Am. Acad. Arts and Sci.*, vol. xx (1884), p. 116.

[2] Hay, W. P. *Loc. cit.*

ARTIFICIAL INCUBATION OF ALLIGATOR EGGS.

ALBERT M. REESE.

THE writer received, about the first of August, 1900, a lot of alligator eggs from southern Georgia, and in order to get a series of embryos at different stages of development, it was necessary to find some means of incubating the eggs artificially.

As is well known, the Florida alligator lays her eggs, about thirty in number, in a so-called nest, which she constructs of sticks, leaves, earth, etc., on the banks of the pond or stream in which she lives. The eggs are laid in the cavity of this nest, and are carefully covered and allowed to incubate by the heat of the sun. When the young alligators are about ready to hatch, they make a curious squeaking noise, which attracts the mother's attention, and she uncovers the eggs so that the young alligators may not be smothered in the nest after they escape from the eggs.

The lot of eggs above mentioned was sent by express from Georgia to Baltimore, and arrived in good condition, being packed in damp leaves and *humus*, probably from the native nest. Several of the eggs were at once opened, and were found to contain living embryos in an advanced state of development.

As the incubator which is ordinarily used for chick eggs was not in operation, an attempt was made to imitate nature, and the eggs were put into a large bucket of the loosely packed *humus* in which they had been received. Two thermometers were thrust into the *humus*, one deep down to the bottom of the bucket, and the other near the surface. The whole artificial nest was covered with thick cloths and put in the sun to warm. Before sunset the nest was brought into a small room which could be tightly closed to prevent any very decided fall in temperature. The weather was intensely hot at this time,

so that no difficulty was experienced in keeping the eggs at a sufficiently high temperature. By very careful watching, the temperature of the eggs was kept fairly constant, the extremes being 32° C. and 40° C. In spite of this care, the embryos within the eggs were kept alive only a little over one week, and whether they were killed by too great heat, too little air, or too great variation in temperature, it was not easy to decide. It would seem that in nature the eggs must be subjected to a much greater range of temperature than they were in this case, so it seemed probable that it was lack of air that caused the death of the embryos.

Towards the end of August a second lot of eggs was received, but the contained embryos were in such an advanced state of development that most of the eggs were opened and the young alligators preserved for anatomical study. When the shells were opened the young alligators would wriggle out, snapping their little toothless jaws and blinking their eyes, although there was still a mass of unabsorbed yolk protruding through the abdominal wall as large as a pigeon's egg.

A few of these eggs were packed in a small box of damp *humus*, to prevent drying, and were kept in an incubator at a temperature of 37° C. On opening the incubator a couple of weeks later, curious squeaking sounds were heard coming from the inside of the eggs, the sounds which, in nature, tell the mother that her young are about ready to hatch and should be helped out of the mass of earth and leaves in which they are buried. These sounds are audible at a distance of fifteen yards or more, so that even when the eggs are buried in the nest the parent is probably able to hear the call of her young. The next day after the first sound was heard one of the alligators broke out of its shell, and a couple of days later two more hatched; the rest of the eggs proved to be infertile.

During the act of hatching, the young alligators would snap at the fingers, or any small object, quite savagely; but after finally escaping from the egg they could not be induced to do so. The umbilical scar persisted for some time after hatching, but gradually disappeared. The alligator is about 20 cm. in length when hatched, and that an animal of its bulk should

have been contained in so small an egg is quite astonishing. These three artificially hatched alligators are now living, in apparent good health, in a glass-covered box in the laboratory. They are fed, about once a week, on small bits of raw meat which are thrown into the shallow pan of water in their box. It is probable that had the first lot of eggs been treated as was the second lot, the desired stages of development might have been obtained.

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THE COLORS OF NORTHERN APETALOUS FLOWERS.

JOHN H. LOVELL.

The dicotyledons, which include about two-thirds of flowering plants, were divided by Jussieu and Enlicher into three divisions — the Polypetalæ, the Gamopetalæ, and the Apetalæ — an arrangement familiar in most of our floras. The highest type of a flower, according to De Candolle, was one that had all the organs present, but inserted separately upon the receptacle; for it may be argued, as A. Gray remarks, that fusion is an arrest of development, and therefore an indication of low rank, or less perfection, than the contrary. Accordingly the Polypetalæ were placed at the head of the vegetable kingdom. The morphological doctrine that the flower is a metamorphosed bud or branch, and that the union of its parts marked an upward progress, was not made the guiding principle in the arrangement of plant families in a lineal series until a comparatively recent date. The miscellaneous group of dicotyledonous families, known as the Apetalæ, were believed to be retrogressive or degraded forms derived from both the Polypetalæ and Gamopetalæ, which had once possessed petals and conspicuous flowers. This division, as originally constituted, was made the receptacle for families the affinities of which were obscure; and, in the absence of knowledge as to its true position, was placed as a sort of appendix after the Gamopetalæ. It required the united labors of Braun, Hanstein, and Engler to determine and place in their proper collocation those families which are clearly reductions, and to point out that those remaining are not derived from the higher orders, but are primitive in character. They are naked blooming, according to Eichler, rather than abortive.

In many of the true apetalous families the perianth has remained rudimentary, and in those of lowest rank has never

been differentiated into calyx and corolla. It is either wanting, or is represented by a number of small scale-like bodies, indefinite in number, sometimes present in the staminate and replaced by bracts in the pistillate flowers; or it may be so ambiguous as to leave its morphological significance in doubt. Gradually in the rise of the flower from its primordial stage the perianth becomes more and more important, until in the pink family, which occupies an intermediate position, the corolla is large and conspicuous. The flowers are very generally wind-fertilized, and, as may be observed in the grasses and sedges, this is not favorable to the high development of the floral envelopes. Mechanical difficulties are also presented by the aggregation of the flowers in a dense inflorescence. For instance, in the staminate ament of the alder, where the calyx is present, I found by actual count in an ament two and a half inches long seventy-seven flowers; while in the staminate ament of the willow (*S. discolor*), of about half this length, there were two hundred and seventy flowers, or seven times as many flowers to an inch in length. There is no room for a perianth, and the office of protection has been assumed by scales and woolly hairs.

Though the larger part of the families are anemophilous or self-fertilized, their coloration is highly interesting as showing what colors the bracts and perianth would develop naturally as the result of chemical and physical influences, and in a limited number of cases the effect upon such flowers of insect visitors at a later period.

Lowest in rank of the choripetalous series stands the order of the Piperales, with perfect flowers in slender spikes destitute of a perianth, and divided, according as the carpels are separate or distinct, into the Piperaceæ and Saururaceæ. The former is a tropical family, but the latter is represented in eastern America by *Saururus cernuus*, lizard's tail, a name suggested by the slender spike with drooping apex. The flowers are fragrant, with white stamens, and probably attract insects.

A large number of shrubs and trees have the flowers in aments and are frequently referred to as the Amentaceæ. They are widely distributed throughout the temperate and

northern regions, and have been developed to endure severe climatic conditions. They are or were wind-fertilized, the monœcious or diœcious flowers appearing in early spring, when there are no leaves to intercept the pollen.

There are about thirty-five species of the Juglandaceæ, which include the walnut and hickory, large trees valuable for timber and fuel. The flowers are green; the staminate form a long drooping ament, while the pistillate are solitary, or few in a cluster. The perianth is present in both forms. In Juglans there are four narrow petals in the sinuses of the calyx; but in Hicoria they are wanting. An abortive ovary rarely occurs in the staminate flowers.

In the Myricaceæ, or bayberry family, neither the male nor female flowers possess a perianth, but its place is taken by several bracts near the flower.

The Salicaceæ form a large family confined almost entirely to the north temperate and arctic zones. It includes the poplar and the willow. The poplar has no perianth, but the receptacle is extended to form an oblique, cup-shaped disk. In early spring the pollen is expelled forcibly a short distance by the elastic purple anthers. In the genus Salix so variable are the species and so freely do they hybridize that any entirely satisfactory treatment from a systematic standpoint is impossible. The Swedish botanist Anderson, whose standard monograph, published in the Prodromus of De Candolle, was the work of nearly twenty-five years, declared that he never saw two specimens of *Salix nigricans*, which has one hundred and twenty synonyms, that were exactly alike. In Great Britain the number of species have been placed all the way from twelve to eighty. This genus is exceedingly interesting to the evolutionary botanist, since it so fully refutes the ancient dogma of the constancy of species. Though the flowers were formerly anemophilous, they are now fertilized by insects. There is an abundance of honey, a sweet perfume, and the bright yellow stamens render the blossoms very conspicuous. As an evidence of their attractiveness, it may be mentioned that they are collected in England for decorative purposes on Palm Sunday, and are offered for sale in New England cities by

street flower-venders. In *S. candida* and *S. purpurea* the anthers are red, and in the former the style is also dark red; but usually the anthers are yellow. The scales display considerable range in coloration; in *S. purpurea* and several other species they are purple; in *S. nigra*, yellowish; in *S. myrtiloides*, greenish-yellow, capsules reddish-green; in *S. uva-ursi* the scales are rose red at the tip; in *S. humilis* and *S. tristis*, dark red or brownish. The twigs also vary much in color; as green, white-woolly, yellow, brown, red, crimson, and purple. The willows are very attractive to insects and on a warm day they may be observed hovering in clouds about the bright yellow sprays of bloom. The pistillate aments are not so conspicuous as the staminate, and in the case of *S. discolor* attract a smaller number of visitors. On the flowers of this plant I have collected five bees, nine flies, and two beetles. Species of Andrena, seeking food for their young, and flies are very common.

The inflorescence of the Betulaceæ, birch family, is anemophilous, and usually monœcious There is no corolla. In Carpinus, Ostrya, and Corylus the calyx is present in the pistillate flowers but wanting in the staminate; conversely, in Betula and Alnus the staminate flowers have a calyx and the pistillate have not. Originally the calyx was doubtless present in both forms. Its presence or absence in the one sex or the other of the different genera has been largely influenced by mechanical conditions. In the fertile flowers of the hornbeam, hop-hornbeam, and the hazel there are but few blossoms in the capitate inflorescence, while the sterile flowers are more densely aggregated. An opposite condition prevails in the birch and alder, where, though both kinds of aments contain numerous flowers, they are more densely aggregated in the fertile than in the sterile. Where declinic flowers are solitary, or few in a cluster, as in Fagus, Castanea, Asparagus, and *Ribes nigrum*, both forms possess a perianth. The hazel (Corylus) derives its English name from the color of the nuts, as "in hue as hazelnuts," Shakespeare, *Taming of the Shrew*, II, 1.[1] The staminate aments are yellow, and in autumn the leaves also become

[1] *Enc. Brit.*, vol. xi, p. 548.

a handsome yellow. The thread-like stigmas of the pistillate are bright scarlet. In *C. purpurea* the leaves, husk, and pellicle of the kernel are purple. The hornbeam has the anthers pale yellow and the inner bark yields a yellow dye. In the genus Betula the flowers are greenish-yellow and the leaves are a pale yellow in spring and a bright yellow in autumn. The aments of Alnus are a reddish-brown, and the leaves turn to a dull dark brown. The styles, as a rule, in early flowering spring plants are crimson, a coloring which, by converting light rays into heat, favors the growth of the pollen tubes. In several instances I have seen the male flowers of *Alnus incana* visited by the honey-bee for pollen. Müller states that he has seen numerous honey-bees collecting pollen on the male flowers of the European species of hazel (*Corylus avellana*).

In the Fagaceæ, or beech family, there are no petals, but the calyx is present in both kinds of flowers. In the beech, one of our handsomest trees, the greenish-yellow calyx is bell-shaped, 5–8-cleft in the staminate, but 6-lobed in the pistillate flowers. The inflorescence is in small clusters. In the chestnut (*Castanea dentata*) the flowers are exceedingly abundant and give a yellowish tinge to the whole tree. The staminate flowers may contain an abortive ovary and the pistillate five to twelve abortive stamens; the former are in aments, the latter clustered several in an involucre. The flowers of the oak are greenish, sometimes reddish, as well as the scales of the involucre and the leaves in autumn. The species of Quercus are exceedingly variable. Of *Q. robur* there are twenty-eight varieties, while several other species have from eight to ten. No sharp line of demarcation is possible, as they grade into each other by many intermediate forms. At the time of his revision of the family De Candolle wrote, "It is difficult to believe that above one-third of the actual species in botanical works will remain unchanged." The wood of the Fagaceæ is commonly brown or reddish-brown, the inner bark of *Quercus velutina* (*tinctoria*) is orange and yields a yellow dye.

It has been shown that the scales and perianth of the Amentaceæ present a wide range of coloring, including nearly every hue save blue. If the flowers were once entomophilous, as

has been maintained, and are the result of extensive degeneration, then these colors may be the relics of an earlier higher stage. But if the perianth has always remained rudimentary, and the form of the inflorescence has been developed in connection with wind-fertilization, then the coloring is due largely to chemical and physical conditions. It is desirable to consider briefly the origin of the ament, for which the Fagaceæ present special advantages. The ament, though frequently referred to as a spike, is in reality a contracted panicle. It is composed of clusters of flowers with a common involucre arranged around a central axis or rachis, and is, consequently, a branch system with the lateral axes of the first and second order, which would bear solitary flowers, aborted or eliminated. In the oak the female flower still remains solitary, and with the involucre of many bracts represents a non-developed branch; further steps are presented by the beech with two flowers, and the chestnut with several in an involucre. The association of these clusters along a common rachis would produce an ament, the production of which is the result of contraction and concentration, of elimination of axes, and arrested development. There is no evidence that the perianth was ever large and well developed. The primitive flowers were probably perfect and possessed a simple and undifferentiated perianth, which in certain genera has been wholly or in part replaced by bracts or scales. The Piperales are regularly perfect, and rudimentary ovaries and stamens are of frequent occurrence in the Amentaceæ, especially in the Fagaceæ. The causes which have led to the separation of the sexes are still involved in much obscurity, though it is well known that nutrition and climate influence differently the stamens and pistils. It is evident, however, as Darwin has remarked, that cross-fertilization must have been assured before the flowers became declinic, since otherwise the species would have perished. When the antiquity of these families, their wide geographical distribution, the vast number of individuals, — in the case of the birch forming vast forests in Russia, — as well as their floral structure, are considered, there seems no reason to suppose that the flowers were ever entomophilous and conspicuous.

The order of Urticales does not show any advance in the structure of its flowers over the Fagales. The order is a large one, comprising some fifteen hundred species, distributed chiefly through tropical regions. The flowers are small, in inconspicuous spicate or axillary clusters, greenish, and anemophilous. In Ulmus (elm), of the Ulmaceæ, the flowers are a reddish-purple, and the wood of *U. fulva* is reddish also. The Moraceæ, mulberry family, is composed of trees and shrubs with milky juice. The flowers are greenish, but in fruiting the calyx or receptacle becomes fleshy and bright-colored; in Morus, red-purple and white; in Toxylon, yellowish-green; and in Broussonetia the drupes are red. Of the tropical genus Ficus there are six hundred species, three of which occur in the Southern States. Its manner of fertilization has been the subject of much discussion. The hollow, pear-shaped receptacle is lined with male and female flowers, and pollination is effected by small wasps, which force their way into the cavity for the purpose of depositing their eggs. In fruit the enlarged receptacle becomes deep purple, purplish-red, orange, yellow, and whitish, and is eagerly devoured by birds, especially parrots. The greenish fruiting bracts and achenes of *Humplus lupulus* (hop) bear numerous yellow glands from $\frac{1}{260}$ to $\frac{1}{140}$ inch in diameter. When fresh they are filled with a yellow liquid containing wax and resins and a bitter-tonic medicinal principle called *lupulin*. About one ounce may be obtained from one pound of hops. These glands doubtless protect the flowers from attacks of aphides. Glandular-leaved peach and nectarine trees are less subject to curl, to mildew, and to the attacks of aphides than the non-glandular (Darwin, *Animals and Plants under Domestication*, Vol. I, p. 364). The hop in some years is attacked by vast numbers of *Aphis humuli*, and is also subject to blight from a parasitic fungus. The flowers of the nettle family are green, wind-fertilized, and the pollen is scattered by the explosion of the anthers.

The order Santalales includes about seven hundred and fifty species, which are most abundant in tropical regions, only six species being found in the Northern States. The two northern species of the Loranthaceæ, mistletoe family, are parasitic

plants which contain chlorophyll, and are yellowish or brownish green. Tropical species of Loranthus produce magnificent flowers 10–20 cm. in diameter and display most gorgeous orange and purple colors. The flowers of the Santalaceæ, sandalwood family, are perfect, the calyx is greenish-white or purplish, and at least one species in Europe has been seen to be visited by the honey-bee.

The colors of the Balanophoraceæ, a tropical family parasitic on the roots of forest trees, which belongs also to this order, are of much interest. The plants, of which there are about forty species, resemble fungi, such as toadstools, producing flowers. They were, according to Kerner, made the subject of many fanciful speculations by the nature-philosophers, by whom they were considered as "in the position of a hieroglyphic key between two worlds." The entire plant of the American genus Langsdorffia is pale yellowish or, in the case of the scales, waxen yellow, orange, or red. The genus Balanophora occurs in the eastern hemisphere and is vividly colored a deep yellow, red, or purple. In Helosis the floral spadix is purple or blood-red; in *Corynæa turdici*, which lives on the roots of Peruvian-bark trees, the purple spadix is supported by a white shaft. The coloring of the inflorescence of *Lophophytum leandri* "cannot be exceeded," says Kerner, "in variety, its rachis being pale reddish-violet, the bract scales gamboge, the ovary yellowish, the styles red, and the ovaries white." The entire plant of *Sarcophyte sanguinea* from the Cape of Good Hope presents a most striking appearance, owing to the blood-red coloring of all its parts.

The flowers of the Aristolochiaceæ, or birthroot family, are adapted to Diptera, especially to small gnats. The calyx is highly specialized and in Aristolochia, familiar in *A. sipho*, Dutchman's pipe of cultivation, is prolonged into a tube with a contracted throat, either straight or shaped like the letter *S*, which is set on the inside with reflexed hairs. Flies can creep inside easily, but when they attempt to escape they are prevented by the hairs, which form an impassable grating. As soon as the anthers have dehisced, the hairs wither, the calyx shrivels, and the imprisoned insects are set free. The mechanism

of Aristolochia, which was first studied by Sprengel, "was long," says Müller, "the only example known of a temporary prison for insects." Progressive steps toward this structure are presented by Asarum and Heterotropa. The flowers of Aristolochia are lurid purple, with a yellowish-green tube; the tube of Asarum is greenish or brown-purple, puberulent with purple hairs; or in *A. macranthum* the tube is mottled with violet within. According to Kerner, South American species of Aristolochia are of immense size and are used as caps by children at play; in color they are a combination of cream and deep maroon purple. Purplish coloring of bracts and sepals is of so common occurrence, even extending to the whole plant, that in this family it has doubtless been developed directly from the primitive green without passing through any intermediate stage. The flowers should be compared with the pitcher-like leaves of Sarracenia and the spathes of Arum, as all three serve as traps for small flies and are lurid purple, a color probably attractive to these insects. Rudimentary petals occur in *Asarum canadense*.

The flowers of the Polygonaceæ, or buckwheat family, are devoid of petals and are wind-fertilized, as in Rumex, or autogamous or entomophilous, as in Polygonum. In the genus Eriogonum, growing west of the Mississippi, the campanulate calyx is usually yellowish or white, sometimes changing to pink. The calyx of Rumex (sorrel) is small and commonly green, but in *R. venosus* it is red, and the fertile panicles of *R. acetosella* turn reddish; but the achenes, or fruit, are usually red, and frequently the stems and leaves, as in *R. sanguinea*. Red butterflies, which are attracted by red coloration, were often seen by Müller in the Alps seated upon the plants when in seed, and a species of Halictus was observed frequently collecting pollen. The plants of the Polygonaceæ tend to develop red rather than yellow coloration; but in *Rumex persicarioides* (golden dock) the fruiting calyx becomes orange-colored, and the roots of several species of dock are yellow.

Of the thirty-eight species of the genus Polygonum (knotweed) ten are white, ten red, three purple, and fifteen green.

Conspicuousness is gained by the union of the flowers in axillary or terminal clusters. The green flowers are very small, odorless and honeyless, and self-fertilized. The white and red are more conspicuous, may contain honey, and are visited by few or numerous insects; for instance, *P. persicaria* has a white or red calyx, secretes honey sparingly, and is visited by many flies and small bees. The species of this genus most excellently illustrate the successive steps by which a green perianth may become conspicuous. In the common door-weed (*P. aviculare*) the margins of the sepals are white, turning pink, while the centers remain green. The flowers are self-fertilized, but are occasionally visited by flies. In *P. convolvulus* the two inner divisions of the perianth are entirely white, but the outer are keeled with green; the calyx of *P. virginianum* is usually green, tinged or tipped with white; *P. persicaria* has in the same spike green, white, and red flowers; while *P. orientale*, cultivated from India, has large, bright rose-colored flowers. In the case of the familiar buckwheat (*Fagopyrum fagopyrum*) the waving fields of white bloom are very conspicuous. The dimorphic flowers possess perfume, and insects manifest special preference for the honey; in Germany Müller has enumerated forty-one visitors, of which twelve are bees. Cross-fertilization is insured and self-fertilization rendered difficult. The marked tendency of both the vegetative and floral organs in this family to develop reddish coloration is evidently due to bright sunlight and the chemical constitution of the sap, for the Alpine bistort (*P. viviparum*) of the White Mountains often has little red bulblets in place of the flesh-colored flowers. In *P. scandans* and *P. dumetorum* the calyx is yellowish-green.

The Chenopodiaceæ is a large family consisting chiefly of herbs of a homely aspect. To it belong the garden beet and the pot-herb spinach. The green flowers are very small, usually clustered, and in many species unisexual. The calyx is usually present, but is wanting in the pistillate forms of some genera. As in the Polygonaceæ, certain species show a tendency to develop red coloration; *Chenopodium rubrum* has a red calyx, and the inflorescence of *C. album* often turns reddish

in autumn, as well as the stem. In *Blitum capitatum* (strawberry blite) the reddish calyx becomes bright red and juicy in fruit, the globular, axillary heads resembling a strawberry; in *Salicornia herbacea* the whole plant turns bright red in autumn, "forming vividly covered areas in the salt marshes, hence called *Marsh samphire*." The large converging lobes of *Salsola kali* become rose-colored, and the leaves and outer branches of *S. tragus* also turn bright red at maturity. Many of the species are halophytes, most abundant by the sea and in the salt marshes of Central Asia and in the basin of the Great Salt Lake of Utah. The pollen is dust-like and the flowers are anemophilous, or autogamous, though rarely visited by pollen-eating flies. *Dondia americana* has purple-green sepals.

The red coloration noticed in the two preceding families is also highly developed in the Amaranthaceæ. This is not so much observable in our native species as in cultivated forms. The foliage of the ornamental Amaranthus is richly variegated with deep red, yellow, and green, and the flowers are dark red. In *Amaranthus hypochondriacus* from Mexico the entire plant is tinged with red; while the whole plant of *A. melancholicus* from eastern Asia is purplish. The crests of the flowers of *Celosia cristata* (cockscomb) from India are rose, crimson, yellow, and white; in *Gomphrena globosa* (globe amaranth) the dense round heads are crimson, orange, purple, and white. In this family the sepals are separate, or united at base, or in Frœlichia form a tube.

In the Nyctaginaceæ (four-o'clock family) the calyx is campanulate or salver-form, corolla-like, with a deciduous limb. The involucre resembles a calyx. The flowers are entomophilous and mostly pink or red in northern species; but in *Abronia fragrans* the slender flowers are white, fragrant, opening at night and adapted to nocturnal Lepidoptera. Florists offer yellow, white, and red varieties of *Mirabilis jalapa*. The sweet-scented *M. longiflora* is white, with a tube 15 cm. in length and adapted to night-flying Lepidoptera. The limb stands edgewise and is designed to render the flower more conspicuous in the evening and not as a landing place for insects.

The Portulaceæ and Caryophyllaceæ usually possess a corolla, though it is sometimes wanting. The colors of the flowers of the Portulaceæ are white, yellow, and red. *Portulacea oleracea*, which, Warner fitly remarks in his charming essays on gardening, "grows with all the confidence of youth and skill of old age," has yellow flowers and red stems; *P. pilosa* has red flowers, and the intermediate stages between red and yellow are shown by the cultivated *P. grandiflora*. In this latter species the white flowers have green stems, and the yellow and red flowers red stems.

In the Caryophyllaceæ, a large family of some fifteen hundred species, there are in the Northern States fifty-six white, twenty-two red, two purple, and eight green flowers. The green flowers are apetalous. Both the green and smaller white-flowered species are low, tufted, weak herbs of a spreading or ascending habit, represented by the chickweeds and sandworts. The flowers are solitary or, at least, not densely clustered, and usually white, or in Spergularia reddish. The honey is freely exposed and the pollinators are chiefly flies, beetles, and the smaller bees, such as Andrena and Halictus. Certain species are visited also by butterflies and moths and by the cosmopolitan honey-bee. I have never observed and have been unable to find any record in the works of Müller and Knuth of the visits of bumblebees. Many of the species are dichogamous, but self-fertilization is always possible. The chickweed (*Alsine* (*Stellaria*) *media*), so widely distributed as a garden weed, may be taken as a representative species. The individual flowers are quite inconspicuous, but they are numerous and, in contrast with the green foliage leaves, can be seen at a considerable distance. I found on trial that a flower could be distinctly seen at a distance of twenty-five feet; but after removing the petals it was visible only about four feet. The plants blossom throughout the entire year, except when prevented by severe weather, and in early spring and late fall, when there are few other flowers in bloom, are very frequently visited by flies. In April, Müller collected in Germany six of the less specialized bees and four Diptera, and in the middle of October I collected in Maine five species of Diptera

and Andrena. The honey is abundant. In winter the flowers fertilize themselves. The white petals in these genera may in part be due to the non-formation of chlorophyll, and in part to the selective influence of the visitors in choosing the more conspicuous flowers. Insects have also probably aided in the preservation of the petals, for in certain species of Alsine and Sagina they are sometimes present and in other instances are wanting.

The pinks proper, or Sileneæ, exhibit a wonderful variety of red shades, varying from white, through rose, pink, and deep red, to scarlet and crimson. The petals may be dotted or marbled with white, with a white center, surrounded with a purple ring, as in *Dianthus deltoides*. The corolla is often notched or fringed and surmounted by a corona of scales. The perfume is aromatic, and the honey is deeply concealed. The red flowers are very attractive to butterflies, which are the chief visitors, while the white species are adapted to night-flying Lepidoptera. The following table, prepared from Müller's *Alpenblumen* and Knuth's *Handbuch der Blütenbiologie*, shows the importance of butterflies as fertilizers of red flowers.

VISITORS TO RED-FLOWERED SPECIES.

	Length of Tube in Millimeters.	Butterflies.	Millers.	Hymenoptera.	Diptera.	Coleoptera.	Total.
Silene acaulis	10	19	4	3	4	1	31
Lychnis flos Jovis	10	3			1		4
L. ruba	10–13	11	1		1		13
Saponaria ocymoides	10–12	28	5	3	2		38
Dianthus sylvestris	18–25	1					1
D. atrorubens	13–15	4	1				5
D. deltoides	12–14	9	2				11
D. carthusianorum	12	9	6				15

The carmine flowers of *Silene acaulis*, which grows in the higher Alps, are so frequently visited by butterflies that the power of self-fertilization has been nearly lost. Both the species of Lychnis have bright red, beautiful flowers and

attract many butterflies. The handsome red flowers of *Saponaria ocymoides* are very abundant on sunny slopes in subalpine regions and are sought by twenty-eight species of butterflies. The species of Dianthus have the calyx tube so long and narrow that the honey can be reached only by Lepidoptera. The flowers are rose or dark red, elegantly marked, of large size and great beauty. The association of bright red coloration with a slender calycine tube and fertilization by butterflies is not a coincidence, for throughout the Caryophyllaceæ in proportion as the flowers increase in conspicuousness the power of self-fertilization is lost.

"As the honey gets more deeply concealed and access more directly limited to butterflies, we find," says Müller, "*pari passu* among the Caryophyllaceæ increasing development of sweet scents, bright red colors, fine markings round the entrance of the flower, and indentations at the circumference. All these characters which are so attractive to us seem to have been produced by the similar tastes of butterflies." This view is much strengthened when it is considered that the nocturnal flowers of the genera are white, and without variegation. *Saponaria officinalis* is pale pink, or, on expanding, white, with the perfume strongest in the evening; *Silene nutans*, *S. noctiflora*, and *Lychnis alba* all have white or pale pink flowers and are visited by night-flying Lepidoptera. Since red is invisible at night, while white is conspicuous, it is evident that the former color would be disadvantageous to nocturnal flowers. Originally the flowers of these genera were probably pale pink or whitish, as in Gypsophila, where they are small, reddish, the tube short, the honey fully exposed, and the visitors a miscellaneous company of flies, bees, and Lepidoptera. A part of the species became adapted to butterflies and a part to moths; no new colors were developed, but the red and white were differentiated. The sexual markings of butterflies show that they are in a very high degree color-loving insects, and while they visit flowers of all colors they certainly prefer bright hues to dull, and as with rare exceptions butterfly flowers are red, it is probable that they find this color most attractive.

Under cultivation the pinks have proved susceptible of great

improvement, and numberless splendid varieties have been produced of every shade of red, dotted and striped, or marbled and angled with white. In *Dianthus barbatus* (the sweet-william) white and two different shades of red florets may occur in the same fascicle, the white turning pink with age. Florists also offer pure white and yellow forms, and white and yellow varieties bordered with red or purple. Yellow, which is well shown in Dianthus, is a comparatively rare color in the Caryophyllaceæ.

THE COLORS OF NORTHERN APETALOUS FLOWERS.

ORDERS.	FAMILIES.	GREEN OR DULL COLOR.	WHITE.	YELLOW.	RED.	PURPLE.	BLUE.	TOTAL.
Piperales	Saururaceæ		1					1
Juglandales	Juglandaceæ	13						13
Myricales	Myricaceæ	4						4
	Leitneriaceæ	1						1
Salicales	Salicaceæ	9		32	2			43
Fagales	Betulaceæ	7		11				18
	Fagaceæ	25						25
Urticales	Ulmaceæ	3				4		7
	Moraceæ	6						6
	Urticaceæ	8						8
Santalales	Loranthaceæ	2						2
	Santalaceæ	2	2			1		5
Aristolochiales	Aristolochiaceæ					10		10
Polygonales	Polygonaceæ	33	22	5	11	3		74
Chenopodiales	Chenopodiaceæ	38			1			39
	Amaranthaceæ	16	1					17
	Phytolaccaceæ		1					1
	Nyctaginaceæ		1		4	3		8
	Aizoaceæ		1			1		2
	Portulacaceæ		4	3	5			12
	Caryophyllaceæ	8	56		22	2		88
	Total	175	89	51	45	24		384

SUMMARY.

1. The apetalous Choripetalæ (Saururaceæ-Aizoaceæ) are of primitive character; and are, or were, autogamous or anemophilous. In the formation of the dense inflorescence

characteristic of many genera there has been much contraction attended by the elimination of axes, leaves, bracts, and even of the perianth, but the flowers are not degraded entomophilous forms. Consequently, when the flowers possess bright colors they are not the relics of a higher stage of coloration developed by the selective tastes of insects, but are due to the chemical constitution of the nutritive fluids and the action of light and heat.

2. The absence of blue is noteworthy. Yellow is not common, but is well shown in the scales and calyx of Betula. The inner side of the calyx of *Mollugo verticillata* is whitish, and in Polygonum the margins or entire calyx is white. Red is very common and occurs in many genera. Purplish flowers also occur, as *Sesuvium maritimum*. There is evidence derived from this group of families that if anthophilous insects were devoid of color sense, they still would have developed white, yellow, red, and purple flowers, though they would be less frequent and of duller shades.

3. A number of genera have become entomophilous, and this change in the manner of fertilization has been attended by an increased conspicuousness of the flowers. The anthers of Salix, formerly a wind-fertilized genus, have become a brighter yellow; in Aristolochia and Asarum the calyx is a lurid purple attractive to small Diptera; and in Polygonum and several other genera clear white or deep red. Insects have not in these instances produced new colors, but have intensified those already partially developed.

4. Petals are usually present in the Portulaceæ and Caryophyllaceæ, and are white, yellow, red, or purple. The smaller white flowers of the Caryophyllaceæ are visited by flies, beetles, and the short-tongued bees, which may have aided in the preservation of the petals and in rendering them a clearer white. The larger red and white flowers are correlated with the visits of Lepidoptera; the red species with butterflies, the white nocturnal forms with moths.

WALDOBORO, ME.

PREHISTORIC WORKSHOPS AT MT. KINEO, MAINE.

C. C. WILLOUGHBY.

The porphyritic felsite of Mt. Kineo, Moosehead Lake, was one of the chief minerals used for the manufacture of chipped implements by the tribes of central and southern Maine. Chips and broken implements of this stone were found in nearly all of the camp sites and shell heaps which I have examined in that state. The oldest New England people of whom we have knowledge, and whose art remains were taken from the very ancient graves explored by me in Hancock County, Maine, in 1892–94, used knives of this mineral.

Although erratic bowlders of this stone furnished a limited supply of material, the chief source was the great cliff of Kineo. The southern side of this mountain is a mile or more in length and rises nearly perpendicularly to a height of several hundred feet. Its opposite side slopes gradually to the wooded plain forming the northern portion of the peninsula.

FIG. 1. — Sketch showing approximate cross-section of Mt. Kineo; *a*, talus slope.

In connection with other archæological work in Maine carried on under the auspices of the Peabody Museum of Harvard University, the writer made two visits to Mt. Kineo, for the purpose of locating Indian workshops and learning the manner in which the rock was quarried or otherwise obtained.

The talus slope at the foot of the great cliff of Kineo (Fig. 1, *a*) is from two hundred to three hundred feet in width and extends the entire length of the mountain. Patches of evergreens interspersed with deciduous trees are growing near its base, but its surface is practically free from soil. The slope of the talus is composed of comparatively small fragments

intermixed with larger masses of the rock. This talus is constantly forming, and the colored patches along the face of the cliff mark the places from which masses of felsite have recently fallen, which are shattered as they strike the rocks below, and the larger pieces rolling down the slope are chipped and broken into innumerable forms. The recently fractured pieces are easily distinguished from those which have been long exposed to the action of the atmosphere. The fresh fracture presents a green surface sprinkled with small dots and squares of gray feldspar crystals. Upon long exposure the surface becomes a uniform dirty gray. Upon this slope one can gather bushels of chips, flakes, and pseudo-implements wholly the work of nature, which, if placed unlabeled on the shelves of a museum, would be accepted without question as the work of man. For comparison a series of these natural forms is shown with an equal number from Indian workshops at a distance from the mountain. In selecting the natural forms care was taken to include only those lying on the surface near the top of the talus and having the green color indicating freshly fractured stone. Only a few of the many examples collected are shown. The natural forms are illustrated on Pl. I, *g* to *l*. The artificial forms from the workshops are shown upon the same plate, *a* to *f*. Typical artificial chips showing the "bulb of percussion" are seen in *e* and *f*, while *k* and *l* show natural chips having corresponding bulbs. These "bulbs of percussion" are generally accepted as conclusive evidence of the artificial origin of such flakes.

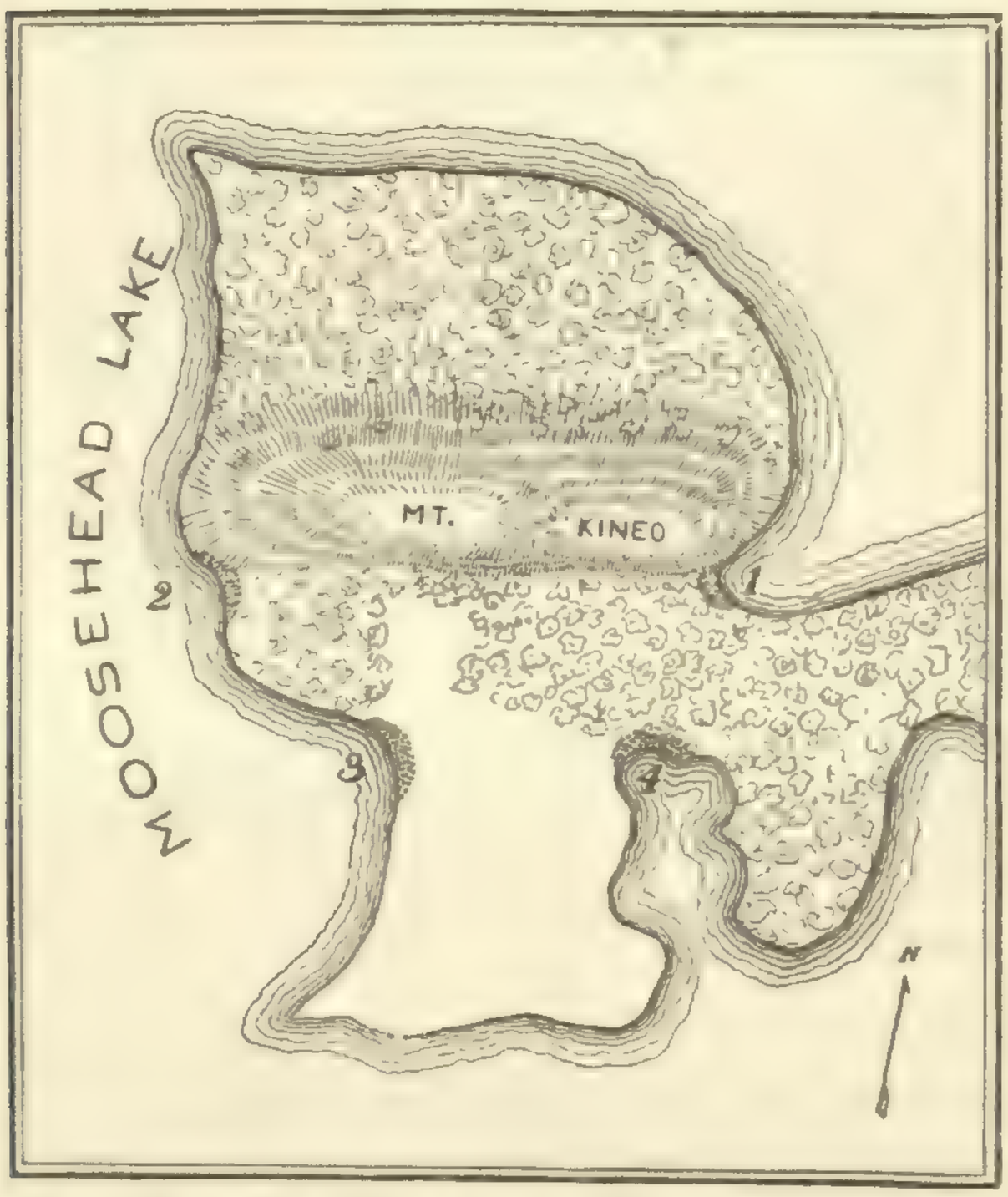

FIG. 2. — Sketch map of Mt. Kineo and vicinity, showing location of Indian workshops.

At points at the lower edge of the talus slope and in several places on the low peninsula south of the mountain were indications of former occupancy by the Indians. Chips and rejectage occurred in many places, but the principal workshops were located at the points indicated upon the sketch map (Fig. 2). Workshops 1 and 2, near the eastern and western ends of the cliff, were evidently the principal blocking-out shops. These, being near the water, had unfortunately been disturbed and partially destroyed by the waters raised by damming. A large amount of chips and general shop refuse was found at the eastern shop (1). Large discarded worked nodules lay in beds of chips. Ashes and charcoal occurred at intervals. A few hammer stones were found, all of felsite. The rejectage of this shop indicated principally the production of large implements. Very few nearly completed implements were found.

Workshops 3 and 4 differed principally from those at the foot of the talus in the size of the rejectage. Both had been somewhat disturbed by the damming of the outlet of the lake and the consequent washing away of portions of the shore. Workshop 4 had been nearly obliterated, but the abundance of refuse along the beach showed the types of implements manufactured there. In both these workshops medium and small "turtlebacks" predominated.

The ruder forms of rejects collected from the different workshops are illustrated upon Pl. II, *a* to *e*. These occurred in great abundance, the larger examples being nearly all from the shops at the foot of the talus slope. Types of the secondary forms are shown on Pl. III, *e* to *h*. These were much less abundant than the ruder forms. The largest specimen, *e*, measuring eighteen inches in length, was found by Mr. L. L. Hubbard in workshop 3, and presented by him to the Peabody Museum.

Comparatively few implements broken in the last stages of formation were found. The lengths of the perfect examples of which these were a part would range from about three inches to ten inches. Unbroken finished or nearly finished implements were very rare. They were of the types shown upon Pl. III, *a* to *d*.

I could find no evidence that the rock used was detached from the main mass by the Indians. The material was evidently taken from the talus, fractured pieces being selected of the size and form most readily chipped into the implement desired.

That most of the products of the Kineo workshops were intended for transportation and to be finished at a distance is evident not only from the workshop refuse itself but from the chips and more highly specialized forms of this material, both broken and perfect, which are found in nearly all the burial places, village and camp sites which I have examined in central and southern Maine. Small chips of Kineo felsite are very abundant in nearly all the village sites in the valleys of the Kennebec and Penobscot rivers and their tributaries, and also in the camp sites and shell heaps of the inlets, smaller rivers, and islands along the coast between these rivers, and for some distance east of the Penobscot and west of the Kennebec. The broken or discarded implements found in company with the chips in these places are more commonly small knives and projectile points of various forms, together with scrapers and perforators, types common in most prehistoric Indian village sites, but absent or only occasionally found at the Kineo workshops.

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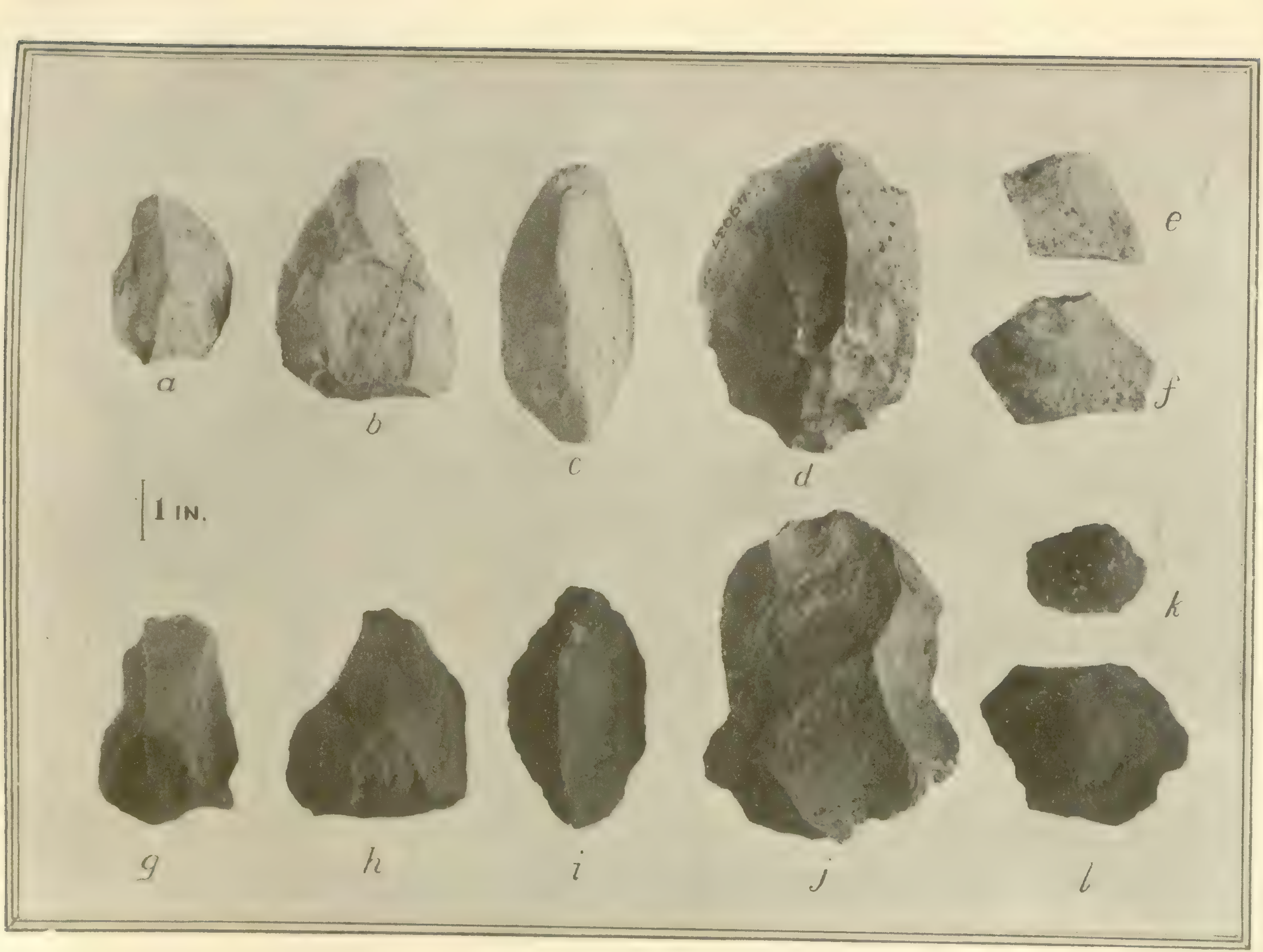

PLATE I. — *a–f*, typical rejects and chips from Indian workshops, Mt. Kineo, Maine.
g–l, natural forms from the talus.

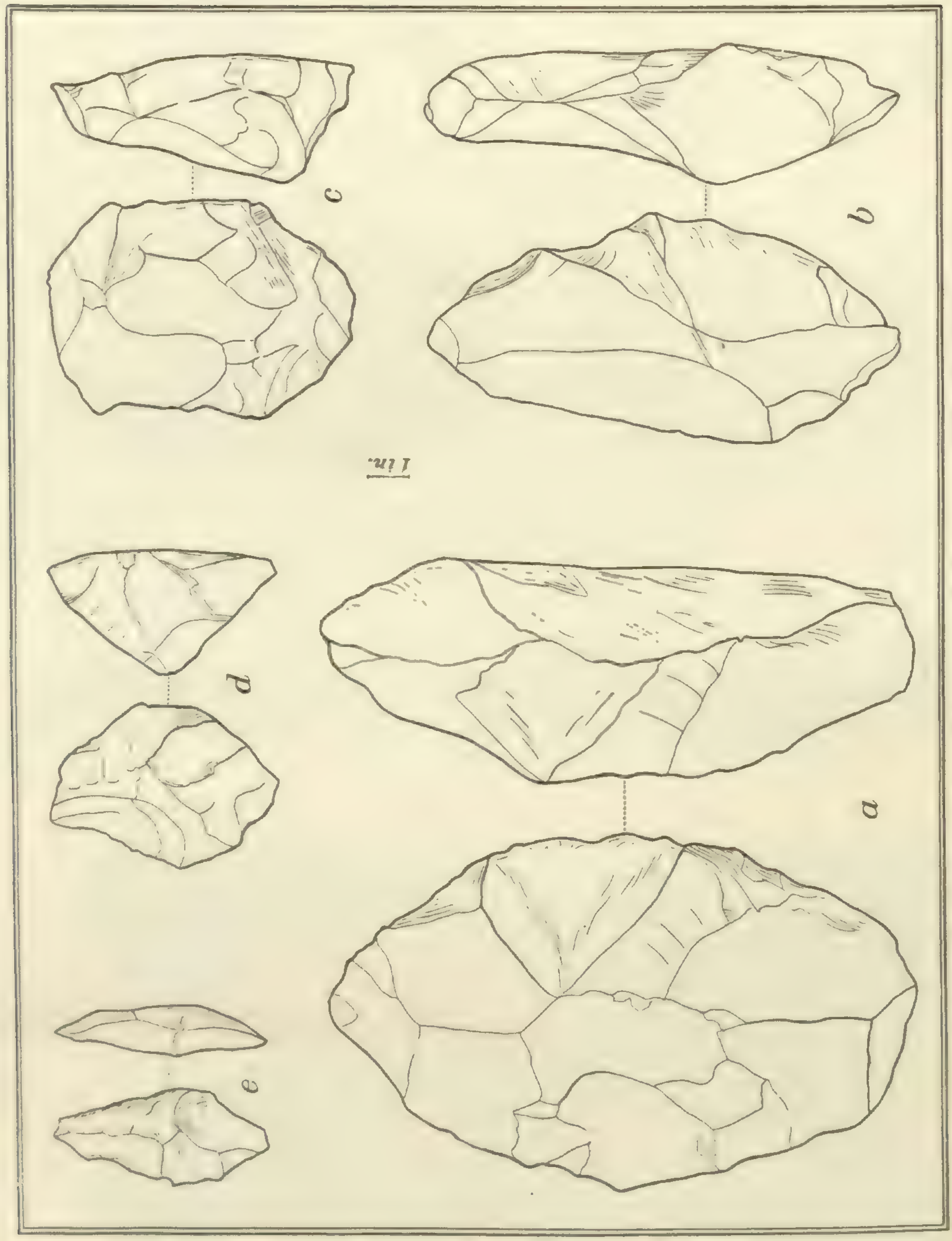

PLATE II.— Chipped nodules (rejects) from Indian workshops, Mt. Kineo, Maine.

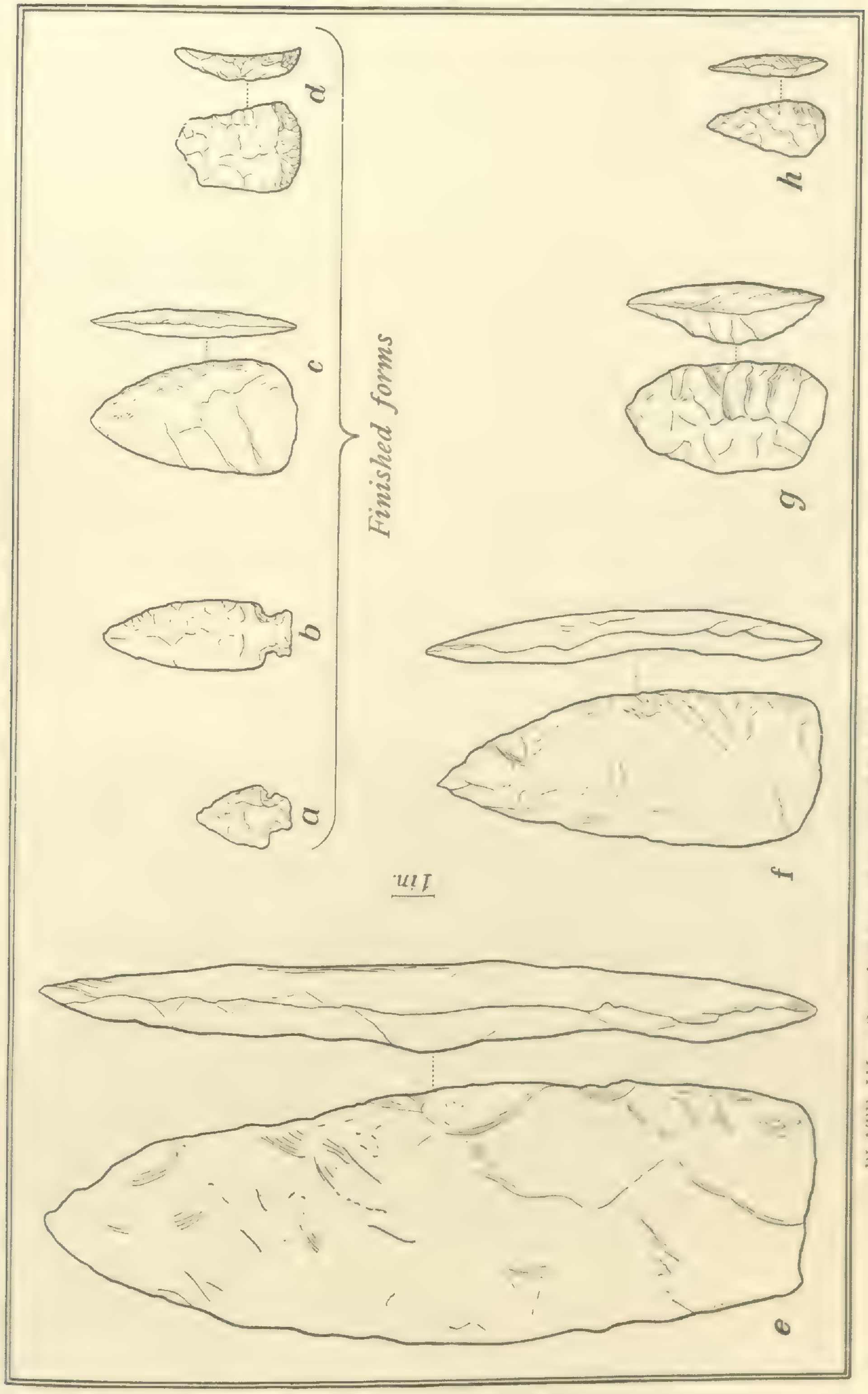

PLATE III. — Secondary forms (rejects) and finished implements from Indian workshops, Mt. Kineo, Maine.

REVIEWS OF RECENT LITERATURE.

ZOÖLOGY.

Two Important Papers on North-American Mammals. — The literature relating to recent work on North-American mammals is so scattered, and the results have been the outcome of investigations by such a number of different workers, and based on such varying amounts of material, that it is a great gain when a competent authority on any given group can go over it and coördinate the efforts of his predecessors in the light of, practically, all of their material, combined with a vast amount in addition. In other words, the monographic revision of any of the larger genera of North-American mammals by an expert is a distinct advance, for which all mammalogists may well feel grateful. It is with pleasure, therefore, that we call attention to two recent contributions of this character — Mr. Vernon Bailey's "Revision of American Voles of the Genus Microtus," and Mr. W. H. Osgood's "Revision of the Pocket Mice of the Genus Perognathus."

Mr. Bailey's revision[1] of the American voles, or meadow mice, is "based on a study of between five thousand and six thousand specimens from more than eight hundred localities, including types or topotypes of every recognized species with a known type locality, and also types or topotypes of most of the species placed in synonymy." With such material at command, and with a wide experience with the animals in life, and personal knowledge of the actual conditions of environment over a large part of the range of the group, Mr. Bailey has had peculiar advantages for his work, and his results are subject to revision only at points where material is still deficient, or from some other point of view. This revision, while obviously not final, presents a new starting point for future workers, and is likely to be a standard for many long years to come.

The little animals here treated are the short-tailed field mice,

[1] Revision of American Voles of the Genus Microtus. By Vernon Bailey, Chief Field Naturalist, Division of Biological Survey, U. S. Department of Agriculture. Prepared under the direction of Dr. C. Hart Merriam, Chief of the Division. *North American Fauna*, No. 17, pp. 1–88, with 5 plates and 17 text-figures. Issued June 6, 1900.

familiarly typified by our common "meadow mice" of the Eastern States. The group is divisible into several well-marked subgenera, formerly generally known under the generic term "Arvicola," which has had to give way to the less known but older term "Microtus." The group is especially distinctive of the northern hemisphere north of the tropics, and is found throughout North America from the mountains of Guatemala and southern Mexico northward, increasing numerically, both in species and individuals, from the south northward till it reaches its greatest abundance in the middle and colder temperate zones, again declining thence northward to the Arctic coast. They are vegetable feeders, and often do considerable damage to trees and crops; they are active in the winter, forming long burrows or tunnels under the snow; they are also very prolific, breeding several times a year, young being found throughout the warmer months.

The seventy species and subspecies recognized by Mr. Bailey are arranged in nine subgenera; between the extreme forms the differences are strongly marked, but the intermediate forms present gradual stages of intergradation. The subgenus Neofiber, of Florida, embracing the round-tailed muskrat, and the subgenus Lagurus, of the semi-arid districts of the northwestern United States, present the most striking contrast, not only in size but in many other features. The former is perhaps the largest known vole, while the latter group includes the smallest.

Mr. Bailey's paper, being a synopsis rather than a monograph, leaves much to be desired in point of detail, but is admirable in its way, and covers the ground with as much fullness as his prescribed limits would permit. Of the twenty-six synonyms cited, it is noticeable that thirteen relate to our common eastern meadow mouse, and date from the early authors, while two other eastern species furnish three others, also of early date. Only six of the remaining ten are of recent date, showing that of some fifty-five forms described within the last ten years, by nine different authors, forty-eight meet with Mr. Bailey's approval. Four of the remaining seven are identified with earlier names which for many years have been considered indeterminable, but which Mr. Bailey claims to have established on the basis of topotypes.

While he may be correct in these determinations, it would have been of interest to his fellow-specialists if he had stated the basis of his determination of certain type localities, notably those of Richardson's species, described as from the "Rocky Mountains," or similarly

vague localities. If he has some "inside history" to fall back upon, it is only fair that the secret should be made public.

It may be said further, in the way of gentle criticism, that it is hardly fair wholly to ignore such knotty points as the allocation of a few names which he omits, since they form part of the literature of the subject, as, for example, *Hypudæus ochrogaster* Wagner, *Arvicola noveboracensis* Richardson, and some of Rafinesque's names. Mr. Bailey describes as new two species and one subspecies.

Mr. Osgood's "Revision of the Pocket Mice"[1] is an equally welcome contribution, and has been prepared upon much the same lines, with equal advantages in the way of material and field experience. The pocket mice of the genus Perognathus are confined to a limited portion of North America, being found only west of the Mississippi, and ranging from the southern border of British Columbia south to the valley of Mexico. They are strictly nocturnal and live in burrows, are partial to arid regions and seem to thrive even in the most barren deserts. Their habits are hence not well known, as they are very shy and even difficult to trap. They are mouse-like in form, but only distantly related to the true rats and mice. Their most obvious character is the possession of cheek pouches which open externally.

The pocket mice vary greatly in size, form, and in the nature of their pelage, which may be either soft or hispid; but between the wide extremes there are so many closely connecting links that it is difficult to find any sharp lines of division, although two subgenera are fairly recognizable. The whole number of forms here recognized is 52 — 31 species and 21 additional subspecies, about equally divided between the subgenera Perognathus and Chætodipus. Of these, thirteen are here for the first time described. Out of a total of 61 specific and subspecific names applied to forms of this group, 9 are relegated to synonymy. Of these 61 names, it is interesting to note that 52 date from 1889 or later, and that of these, eight prove to be synonyms, three of them having become so through the identification of older names thought ten years ago to be indeterminable, but since reëstablished on the basis of topotypes.

A previous revision of this group was made in 1889 by Dr. C. Hart Merriam, on the basis of less than two hundred specimens —

[1] Revision of the Pocket Mice of the Genus Perognathus. By Wilfred H. Osgood, Assistant Biologist, Biological Survey, U. S. Department of Agriculture. Prepared under the direction of Dr. C. Hart Merriam, Chief of Division of Biological Survey. *North American Fauna*, No. 18, pp. 1–72, Pls. I–IV, and 15 text-cuts. Issued Sept. 20, 1900.

all of the material then available — when the number of currently recognized forms was raised from six to twenty-one. Dr. Merriam's work, however, cleared the way for a better conception of the group, rectifying important errors of nomenclature and making known many new forms. Mr. Osgood, with fifteen times this amount of material, seems to have settled all of the remaining doubts regarding the application of certain early names, and, besides coördinating the work of his predecessors, has immensely extended our knowledge of the group. The paper is admirable from every point of view and does great credit to its author.

J. A. A.

The Eighteenth Annual Report of the Fishing Board for Scotland. — In this report Thomas Scott gives an interesting local list of the fishes of the Firth of Clyde. The determination of species seems to be accurate, and the nomenclature is more modern than usual in British lists.

Mr. H. C. Williamson attempts by means of very many measurements to ascertain whether a racial difference exists between the mackerel of the east and west coasts of Scotland. He uses the means employed for the distinction of races among men and lately used by Heincke for the definition of races of herring. The Mean, the Probable Error of the Mean, and the Standard Deviation are derived from the formula given in Davenport's *Statistical Methods*.

By these mathematical means the alleged variation in the mackerels of Scotland is elaborately investigated, with negative results, the races not being sufficiently marked to require recognition.

Mr. H. M. Kyle, of St. Andrews, has a suggestive and valuable discussion of the origin and mutual relations of the different groups of flounders and soles. The arrangement adopted agrees in general with that of Jordan and Evermann, which is based largely on earlier researches of Dr. Gill. He would differ from Jordan and Evermann in reducing somewhat the number of genera, and in separating the Paralichthys type as a subfamily distinct from Hippoglossinæ. To this subfamily, which he calls Hippoglosso-rhombinæ, he would add the allies of Syacium and Citharichthys. The soles constitute in his view three additional subfamilies, Achirinæ, Soleinæ, and Cynoglossinæ. The affinities of these groups are obscured by making the soles a distinct family, the three subfamilies being separately reduced or degenerated groups of flounders. To all this there is no serious objection, though Citharichthys and its allies seem to us rather closer to the Psettinæ (or Rhombinæ, as Mr. Kyle prefers to call them,

though the name "Rhombus" is properly used only for another type of fish). The allies of Xystreurys are, moreover, really intermediate between Paralichthys and the Hippoglossinæ.

Mr. Kyle has added considerably to our knowledge of the olfactory structures of the different groups and to our knowledge of the shoulder girdle. His discussion of the origin of the different groups is pertinent and sagacious. It is to be hoped that Mr. Kyle will continue this line of work, and that he may secure specimens and skeletons of the numerous genera which he has not yet examined. We may note in passing that the genus Mancopsetta is of Gill.

D. S. J.

Gill and Smith on American Moringuoid Eels. — A singular group of eels of low structure, and distinguished among other things by the extreme shortness of the tail and the backward location of the heart, is the family of Moringuidæ. It has been supposed to be exclusively East Indian, one species ranging northward as far as the Liu-Kiu Islands of Japan.

Dr. Gill and Dr. H. M. Smith record in *Science* (June 22, p. 973) the discovery of a species of Aphthalmichthys, a genus of this group, from a coral reef near San Juan, Puerto Rico. Further study of this type shows that the very slender whip-like eels of the West Indies, constituting the subfamily Stilbiscinæ, are in fact genuine Moringuidæ. Stilbiscus proves to be identical with Moringua. Gordichthys must belong to the same group and probably Neoconger also, thus giving four genera in America, as compared with the three (Moringua, Raitaboura, and Aphthalmichthys) found in the East Indies. The family is thus almost as well represented in the West Indies as in the East. All the American species are very rare. The species from Puerto Rico is to be described as *Aphthalmichthy caribbæus* Gill and Smith.

D. S. J.

Transplanting of California Trout. — Students of trout in California have noticed a number of anomalies in the distribution of the different forms. The writer has been interested in following these out, and now wishes to place on record for the reference of future naturalists the facts in regard to them. If the investigation had been delayed a few years until the clues were lost, these cases would be altogether inexplicable.

In the tributaries of Feather River, around Prattsville in Plumas County, is found the Lake Tahoe trout, *Salmo henshawi*. I learn

that these trout were placed in Feather River by Mr. Pratt, for whom the town of Prattsville is named.

In the Blue Lakes of Amador County are also found trout transported across the Sierras from tributaries of Lake Tahoe.

In the streams running down the east slope of Mt. Whitney about Lone Pine are found the golden trout of Mt. Whitney, *Salmo agua-bonita*. These were transported by local anglers from Volcano Creek, the isolated mountain stream above Agua-bonita Falls, in which the peculiar form or subspecies has been developed.

This summer Rev. Edwin Sidney Williams, of Saratoga, Cal., transferred twenty young trout, the species not indicated, and a dozen chubs from Pelican Bay on Klamath Lake into the famous Crater Lake of Oregon, an extraordinary body of water without inlet or outlet and, I believe, hitherto without fish life. D. S. J.

An Error Corrected. — In Jordan and Evermann's *Fishes of North America* the generic diagnoses of Collettia and Aëthoprora have been by some unaccountable accident interchanged. It is Aëthoprora which has a luminous gland on the front of the head "like the headlight of an engine."

In the same family of Myctophidæ, *Neoscopelus macrolepidotus* Johnson, dredged by the *Blake* in the West Indies, was omitted by oversight. This genus, with Scopelengys, should apparently form a distinct family, Neoscopelidæ, distinguished by the broad maxillary with supplemental bone.

D. S. J.

Notes on Recent Fish Literature. — In the *Proceedings of the Academy of Natural Sciences of Philadelphia*, Mr. Henry W. Fowler gives an account of the fishes from the Caroline Islands presented to the Academy by Professor Cope. Forty-five species are enumerated, the following new: *Cypsilurus quindecimradiatus*, *Thalassoma immanis*, *Scarus pronus*, *Scarus lupus*. These are illustrated by accurate but rather coarsely engraved plates.

Mr. Fowler gives an account of the typical specimens of *Ameiurus prosthistius* described by Professor Cope from Batsto River, New Jersey. This is regarded by Jordan and Evermann as a synonym of the Florida species of catfish, *Ameiurus erebennus*. But Mr. Fowler's account leaves little doubt of its specific distinctness.

I venture to say that other species in this group will prove to be valid. Especially is it likely that the short-bodied type, called *Ameiurus natalis*, will prove distinct from the common form which has been called *Ameiurus lividus*.

Mr. Fowler redescribes the great catfish of the Florida Everglades, which has been named *Ictalurus okeechobeensis* by Heilprin. He regards it as a subspecies of *Ameiurus lacustris*, but until these great catfishes have been fully studied, it seems as well to regard this, with Jordan and Evermann, as a distinct species.

Dr. Einar Lönnberg, in the *Annuaire* of the Zoölogical Museum of St. Petersburg, gives an account of the discovery by Dr. G. Adlerz of the Opah, *Lampris luna*, on the coast of Murman in Russia. This great pelagic fish is occasionally taken on almost every coast in the world, especially in the northern hemisphere (Nova Scotia, Maine, California, Japan, Madeira, etc.). Dr. Lönnberg adopts the earlier name, *Lampris pelagicus* (*Scomber pelagicus* Gunner, 1768), instead of *L. luna* (1788). But there was already, in 1766, a *Scomber pelagicus* of Linnæus, supposed to be the same as *Coryphæna hippurus*, and the name given by Gunner was preoccupied.

In the *Transactions of the Connecticut Academy*, Vol. X, 1900, Mr. Garman describes three fishes from Bailey Bay, Bermuda Islands, collected by the Yale expedition of 1898. One of these, *Brosmophycis verrilli*, is described as new. This belongs to the section or genus Ogilbia of Jordan and Evermann. *Gobius stigmaturus* is also recorded from Bailey Bay. The original type was from unknown locality, but Jordan and Evermann record the species from Key West.

Dr. Einar Lönnberg writes in the acts of the Swedish Academy of the Saibling of "Bären" Island, as collected by J. G. Andersson. To this form he gives the name of *Salmo umbla* var. *salvelino-insularis*.

In the *Bulletin of the U. S. Fish Commission* Professor J. P. Gorham describes the "gas-bubble disease" of fishes in aquaria. He finds it due to the expansion of gases from the reduction of pressure in removing fishes from deeper waters.

Under the title of "Les Pêches du Hokkaido," the Japanese Fisheries Bureau gives an interesting statistical account of the great salmon and herring fishes of the island of Hokkaido (called Yeso on our maps, but no longer bearing that name in Japan).

Dr. Seth E. Meek has published in the records of the Field Columbian Museum an account of the species of Eupomotis, the group which includes the common brook sunfish. *Eupomotis longimanus* is recognized as probably a valid species.

In a well-printed and finely illustrated volume published by Appleton, Eugene McCarthy tells of the familiar fishes of the rivers of the United States, their habits and the way to catch them. Mr. McCarthy writes best of the phases and places of angling most familiar to him, his first interest being in the Ouananiche or land-locked salmon of Lake St. John. To this useful book a preface has been written by Dr. Jordan.

D. S. J.

North-American Reptiles. — The annual report of the Smithsonian Institution for the year ending June 30, 1898, contains, in addition to a report on the present condition of the United States National Museum, a monograph on the crocodilians, lizards, and snakes of North America, by the late Professor Cope. This noteworthy contribution covers some 1120 pages of text, and is illustrated by 347 groups of text-figures and by 36 plates. It is provided with a separate index. After a brief introduction the groups and subgroups of reptiles are defined and their phylogenetic relations discussed. This is followed by a series of excellent descriptions of the species of crocodilians, lizards, and snakes found in North America. The account is accompanied by keys for the determination of species and by tables illustrating geographical distribution. Considerable attention is devoted to the comparative anatomy of parts important from a systematic standpoint, and these are well illustrated by clear but simple figures which fill most of the plates. The account is concluded by a discussion of the geographical distribution of reptiles, particularly in their relation to the North-American fauna.

This work, in connection with the forthcoming volume by the late Dr. Baur on turtles, and Cope's former monograph on the Batrachia of North America, will place North-American herpetology next to our ornithology in compactness and completeness of its systematic treatment.

P.

Porcupine Quills. — The arrangement of the quills and woolly hairs on the eastern porcupine (*Erethizon dorsatus*) has been carefully described by Loweg.[1] In an embryo 18 cm. long the integument of the dorsal and lateral aspects of the body was covered with short transverse rows of developing quills. Each row was composed of some nine quills, the middle ones being longer than those

[1] Loweg, T. Studien über das Integument des Erethizon dorsatus, *Jena. Zeitschr. f. Naturwiss.*, Bd. xxxiv (1900), pp. 833–866, Taf. XXVII, XXVIII.

near the ends of the row. The rows were so placed on the surface of the body as to form bands transverse to the animal's chief axis. In any given band the rows constituting it alternate with those of the two adjacent bands. The rows of quills break the integument up into plate-like areas, which the author interprets, in accordance with the conclusions of Weber and of others, as the remains of scutes with which the ancestors of mammals are supposed to have been covered. Judging from the condition of the integument in the porcupine, these scutes were large and well developed dorsally and small and poorly formed ventrally. In the porcupine the woolly hair makes its appearance much later than the quills, and may be formed on the scute areas. Phylogenetically the quills represent the primitive hairs, and these are distributed in conformity to the primitive scute covering. The woolly hairs, on the other hand, are a much later acquisition, and are distributed without respect to the places once occupied by scutes. As the skin of the porcupine contains no sweat glands, the animal will probably be found to have a summer and a winter pelage as an adaptation to temperature changes. P.

Human Physiology. — The last addition to the series of Temple Primers is entitled *The Human Frame and the Laws of Health*,[1] and is a translation by F. W. Keeble from the German of Rebmann and Seiler. The first ninety-five pages are devoted to the more salient facts of human anatomy and physiology, and the remaining fifty to hygiene. The presentation is remarkable for its clearness and its general freedom from misstatements such as so frequently mar texts intended to be popular. Here and there slight slips are to be noticed: thus, on page 24 we are told that without the influence of the nerve the muscle cannot contract, and on page 30, in the description of the brain, we are informed that the third ventricle gives off three clefts, lateral ventricles, on either side. Further, on page 139, the distinction between smell and taste is inadequately made out, and the subject is left in the confused state in which it exists in the popular mind. Occasionally inapt expressions are met with, as when (p. 31) the cerebral hemispheres are said to be marked out into two *unequal halves* and (p. 99) ozone is described as a *condensed* form of oxygen. Even such small defects as these, however,

[1] Rebmann and Seiler. *The Human Frame and the Laws of Health.* Translated from the German by F. W. Keeble. 148 pp. The Temple Primers. London, Dent & Co.

are comparatively rare, for the book as a whole is a remarkably trustworthy condensation of the chief facts of human physiology and hygiene. P.

As to "Social Ascidians." — In a recent brief paper M. Maurice Caullery [1] adds one more to the numerous instances brought to light in recent years tending to obliterate the distinction between social and compound ascidians. The case now reported is likely to be noticed more than the others have been, in that it relates to the genus Clavelina, which is one of the ascidians most familiar to the general zoölogist, and is usually given in text-books as a type of the social ascidians.

In this genus the ascidiozoöids, it will be recalled, bud from a stolon, but remain entirely distinct from one another, excepting for their connection with the common stolon. In the species here described (there are two of them) the ascidiozoöids differ structurally in no way from a typical Clavelina; but, instead of being connected to the common stolon only, *they are fully imbedded in a common testicular mass also.*

It is obviously necessary, Caullery says, to establish a new genus for these species; and the name proposed is Synclavella.

Had the author's acquaintance with the literature of this subject included the case of *Perophora annectens* described by me seven years ago, he would not, perhaps, have been so sure about the necessity of a new genus for his species. In this one species I showed (*Proc. Calif. Acad. Sci.*, Series 2, Vol. IV, p. 37) that "in very many, though not all, of the colonies the ascidiozoöids are as completely imbedded in a common test as they are in Botryllus or Goodsiria."

This species is exceedingly abundant at various points on the California coast, and one may frequently observe transitional states between social and compound on the same rock, and apparently in the same colony. I may now add that, after having studied them for a number of years, I have about reached the conclusion that the social condition is the usual one; and that the compound condition occurs only occasionally, even in the same locality. At Pacific Grove, for example, where the most perfect instances of the compound phase have been found, I have, on several visits, failed to find any at all of this kind. It is an interesting fact, also, that

[1] Sur des Clavelines nouvelles (Synclavella *n.g.*), constituant des cormus d'Ascidies composées. *Comptes Rendus*, No. 21, May 21, 1900, p. 1418.

sometimes, at any rate, the ascidiozoöids of these fully compound colonies are noticeably smaller than those of the social forms.

The specimens studied by Caullery were collected by Lesson in 1825, locality not given; and by Quoy et Gaimard in 1829 on the coast of Australia.

WM. E. RITTER.

Parthenogenesis of the Honeybee. — Weismann [1] publishes an interesting preliminary account of studies on the parthenogenesis of bees, which have been carried on in his laboratory for the past three years. The conclusions of Dzierzon, confirmed by von Siebold and Leuckart, that fertilized eggs always produce workers (or queens), and unfertilized, drones (or males), having been in recent years called in question by practical bee culturists, Weismann deemed it imperative to have the question reinvestigated, especially in view of its great theoretical importance. He accordingly induced one of his students, Dr. Paulcke, to undertake the problem, and the studies thus begun are now being completed by Dr. Petrunkewitsch, another of Weismann's students.

One of the most energetic of the recent opponents of Dzierzon's conclusions has been the editor of the *Wördlinger Bienenzeitung*, F. Dickel of Darmstadt. His experiments seemed to prove that normally *all* eggs are fertilized. Eggs which had been laid in drone cells were transferred to worker cells, with the result that they developed into workers, and *vice versa*. Dickel argued, further, that the evidence of von Siebold and Leuckart, based on the microscopic examination of the eggs, could not be regarded as definitive, now that we know more precisely the phenomena accompanying fertilization. These observers had not examined eggs immediately after they were laid, but only after the lapse of from one to twelve hours. But it is now known that spermatozoa lose their thread-like form within a few hours after the eggs are laid, and are succeeded by the sperm nucleus and sperm aster: in fact, it has been recently asserted that this metamorphosis takes place in bees' eggs within fifteen or twenty minutes after the entrance of the spermatozoön into the egg.

Nevertheless, there is no ground to doubt, says Weismann, that von Siebold saw seminal filaments (even two to four in a single egg), for Blochmann, making use of the sectioning method, has seen the same, and Petrunkewitsch now confirms the observation; but these could have been seen only in von Siebold's freshest eggs, all of which

[1] Weismann, A. Ueber die Parthenogenese der Bienen. *Anat. Anzeiger*, Bd. xviii, Heft 20–21, pp. 492–499, December 5, 1900.

were, however, from *worker cells*. The twenty-seven drone eggs which he examined were all "about twelve hours old," so that his failure to find in them sperm filaments is in no way proof that fertilization had not taken place.

The most of the material for the investigations in Weismann's laboratory was furnished by F. Dickel, who took the eggs from the hives, put them at once into the preservative fluid and sent them to Weismann. The main results are as follows: Whether the egg is fertilized or not can be determined with certainty only when it is killed in the stage of the *second* maturation spindle. Before that, in the stage of the *first* maturation spindle, either the sperm nucleus is without radiations, or the sperm filament has not yet been metamorphosed into a sperm nucleus. In either case it is a matter of chance, depending on location and physical condition whether the sperm cell can be recognized with certainty. In the second-spindle stage, on the contrary, the formation of a sperm aster is completed and the structure can neither be overlooked nor misinterpreted. Petrunkewitsch sectioned 123 eggs that were in the first-spindle stage. Twenty-nine of these were from *worker* cells; in twenty-three cases (79%) the sperm nucleus with radiations was present. On the other hand, *not a single* sperm aster was found in any of the ninety-four eggs from *drone* cells. The condition of eggs in the second-spindle stage was still more striking. *Every one* of the sixty-two eggs from *worker* cells showed the sperm aster; whereas of the 272 eggs from drone cells *only one* contained a sperm aster. It is explained by Weismann that in this one case the queen probably made a mistake and deposited a fertilized egg in the wrong (drone) cell, a phenomenon which bee-keepers have long recognized as occasionally taking place.

Weismann believes, therefore, that Dzierzon's views are fully confirmed, — that normally eggs laid in drone cells are *not fertilized* and that those laid in worker cells are always *fertilized*.

Dickel's observation, that as soon as the queen has laid an egg, workers enter the cell and busy themselves with the egg, probably licking it and coating it with saliva, does not warrant his conclusion that the sex is determined thereby. What the significance of that act may be is not known. That it is of importance seems to follow from the results of some of Dickel's experiments. He isolated a comb containing freshly deposited eggs by removing the workers from it and then enclosing it in fine gauze, without, however, removing the comb from the hive. All such eggs perished sooner or later,

frequently in late embryonic stages. It may be that here, and in other insects whose eggs have a thin chorion, there is need that the egg be coated with saliva to prevent its drying up. Whatever the influence of the secretions of the three pairs of salivary glands, sex in bees is determined by the existence or absence of fertilization. Other conditions within the sex — whether, for example, worker or queen shall result — may be determined (as they apparently also are in termites, according to Grassi's observations) by the quantity and quality of the food, including the salivary secretions. *How* it is that fertilization determines sex is not known, but that it does can no longer be denied.

Dickel has insisted that there is a difference between drones produced by fertile workers and those produced by queens, and he believes that the former are infertile. Weismann says he knows of no proof of this, but admits that the studies of Petrunkewitsch show that there is a slight, though constant, difference in the early phenomena of development between unfertilized eggs from queens and those from workers, and that this may possibly be of importance. Further study on this point is required. A difference between queen-drones and worker-drones is *a priori* in no way improbable; indeed, there is a wasp in which two kinds of drones are known to exist, though it is not known whether these have the same or a different parentage.

M.

Artificial Parthenogenesis. — Following the lead of Morgan and Loeb, who have shown that certain salts can induce the development more or less complete of unfertilized eggs of the sea-urchin, Pieri [1] and Winkler [2] have, independently of each other, tried to induce development of the unfertilized echinoderm egg by means of sperm extract. Their efforts have been at least partially successful, though the observations made are less extensive than might be desired.

Pieri took fresh, sound sperm of *Strongylocentrotus lividus*, or of *Echinus esculentus*, and shook up the same either in sea water or in distilled water. The fluid was then filtered and examined under the microscope. It was found to contain still a certain number of spermatozoa, but these were motionless, rounded, tailless, and, so far as direct observation could show, dead. Unfertilized eggs of the species from which the sperm was obtained were then placed in some of this

[1] Pieri, J. B. (**99**). *Exp.* (3), 7, Notes et revues, *Arch. de Zool.*, p. xxix.

[2] Winkler, H. (**1900**). *Nachrichten v. d. k. Gesellsch. d. Wiss.* Göttingen, *Math.-phys. Klasse*, p. 187.

fluid on a glass slide, and watched under the microscope. A certain number of the eggs developed (without fertilization) up to the morula stage. The fluid was found to be effective in causing the development of unfertilized eggs, even when ten hours old. Control lots of eggs placed in sea water or in distilled water did not develop at all. The sperm extract made in sea water worked better than that made in distilled water, which is not at all surprising considering the known injurious effects of fresh water on marine organisms and their sexual products.

Pieri admits that his experiments would be more convincing if a centrifugal machine and a porcelain filter had been employed in making the extract. He believes, however, the fact to be established that an extract of spermatozoa contains a chemical substance capable of causing the development of unfertilized eggs of the species producing the sperm. This substance he believes to be a soluble ferment, *ovulase* (Dubois, 1900, *Mémoires Soc. Biol. Paris*, 52, p. 197). No evidence is offered in support of this view.

Winkler's experiments and results are similar, though slightly different methods were employed by him to obtain the extract, and greater precautions were taken to exclude from it living spermatozoa. Sperm of *Sphærechinus granularis* or *Arbacia pustulata* was put into distilled water, shaken frequently during half an hour, and the fluid then filtered five or six times through three thicknesses of filter paper. The fluid was then brought up to the density of sea water by adding to it salt obtained by evaporation of sea water.

Sperm extract was also prepared by putting sperm into concentrated sea water (400 c.c. evaporated to 100 c.c.). In this spermatozoa shrunk at once, but were allowed to stand for half an hour, being frequently shaken. The extract was filtered as already described and then diluted to the concentration of normal sea water.

In the extract obtained by either method a certain number of unfertilized eggs underwent cleavage, though the process was not of the normal sort, and it did not progress beyond the 4-cell stage. Stained eggs showed that genuine mitoses occurred. Control lots which were put into sea water, instead of sperm extracts of the same density, did not develop in any instance.

Only negative results were obtained by heating sperm to 50°–60° C. in sea water and placing eggs in the cooled fluid. Winkler expresses no opinion as to the chemical nature of the extract substance which causes the development of unfertilized eggs, but thinks the idea of

Pieri and Dubois that it belongs to the enzymes lacking in support as yet.

The observations which have just been briefly summarized add to the accumulating evidence that fertilization may be essentially a process of stimulation of the egg. This, of course, is true only if one leaves out of account the contribution of hereditary tendencies made by the spermatozoön, which add to the variability of the offspring. The egg, however, apparently contains everything necessary for the production of a new and complete organism like the mother, and needs only appropriate stimulation to start it on its course of development (see Koulagine, 1898, *Zool. Anz.*, 21, p. 653; also Delage, 1900, *Archives de Zool., Exp.* (3), 7, p. 525). In this direction point also the observations of Tichomirov, who showed that the unfertilized eggs of *Bombyx mori* can be made to develop, at least to an advanced embryonic stage, either by dipping them in sulphuric acid or by brushing them; likewise the observations of Dewitz, who obtained cleavage of unfertilized frog's eggs by treating them with corrosive sublimate; likewise the observations of Hertwig, who observed a similar result following the treatment of sea-urchin eggs with strychnine; further, those of Koulagine (already cited), who has induced cleavage of certain fish and amphibian eggs by treating them with the antitoxin of diphtheria; and those of Klebs, who found that parthenospores are formed in conjugating filaments of Spirogyra, in the presence of salt or sugar solutions of appropriate density. Still more emphatically is this indicated by the recent work, already mentioned, of Morgan, and especially of Loeb.

W. E. C.

PETROGRAPHY.

Graphic Representation of Rock Composition and Schemes of Rock Classification. — The recent great increase in our knowledge of rocks and the complexity of their chemical relationships is responsible for the attempts now being made to indicate by graphic methods these relations and incidentally to classify rock magmas on some chemical basis. The differential hypothesis was intended to explain the cause of the chemical relations existing between rock masses. It cannot serve, or at any rate it has not served, as a basis for rock classification. Rocks as objects of study are but portions of differentiated masses. A rock classification must deal with these portions, and it must necessarily deal with well-characterized portions or

types. The difficulty in all classification schemes has been to select such types as will express the essential differences between nearly related rock masses and at the same time to show the relationships existing between them. The graphic method of representing rock analyses by diagrams serves to emphasize the characteristic chemical features of the different specimens analyzed, and to enable the student to recognize readily their differences and similarities. From these diagrams a composite diagram may be constructed, and this represents a chemical type. The chemical relationship of various types is easily read from their diagrams; and classification of the diagrams is a classification of rocks according to chemical composition. The first complete diagrammatic representation of rock composition was suggested by Brögger.[1] His diagrams are polygons drawn from the ends of radius vectors whose lengths correspond to the proportions of the constituents in the rock represented in the diagram. The shapes of the polygons show at a glance the relative importance of the principal components. They are extremely characteristic of the different rock types, and thus may be used to exhibit chemical relationships.

Hobbs[2] makes a few unessential modifications in the Brögger diagrams and combines them to form composite diagrams or diagrams of rock types. This he does, however, not by actually combining the individual polygons, but by averaging the analyses of the rocks which are assumed to belong with the type in question. So far as rock classification is concerned this method is not of great value, since it does not exhibit the differences in composition between the constituent members of the composite and the type produced by them. It affords a very convenient method of exhibiting the peculiar chemical characters of rock families and a concise method of showing their chemical relationships with one another, but the personal element enters so largely into the selection of the rocks that comprise the groups represented in the diagrams that these are not of great use in other respects. If the analyses represented in the diagrams could be averaged in such a way as would take into account the abundance of the various rocks, the composites would possess a high scientific interest. The idea proposed by the author is, however, an excellent one, especially for comparative purposes. It is bound to be received with favor.

Harker[3] suggests a method of using diagrams of rock series

[1] *Das Gangafolgs des Laurdalits*, p. 255. Kristiania, 1898.
[2] *Journ. of Geol.*, vol. viii (1900), p. 1. [3] *Journ. of Geol.*, vol. viii (1900), p. 389.

with a view to determining the mode of origin of certain rock masses. He lays off on a system of rectangular coördinates the proportions of the chemical constituents present in the known members of a series of rocks derived by the differentiation of the same magma, and draws lines through the corresponding points in the figure. Then by interpolation the composition of intermediate members of the series may be determined by inspection. When the lines passing through the points representing the proportions of the constituents present in the various rocks are straight lines, the series concerned is a "linear series," that is, the rates of change in the constituents are constant and their proportion is determined by the percentage of SiO_2 present. This is a "rock series" in Brögger's sense. Such a rock series, however, Harker thinks nonexistent. The normal diagram of a "rock series" consists of curved lines, some of which are concave and others convex. Sometimes when a rock's analysis is plotted the discovery is made that it does not fit into the diagram of the series. Such abnormal rocks may have been formed by the admixture of two magmas, or by the solution of foreign rock fragments in a normal magma. In either case the resulting mixture possesses a peculiar composition, the plotting of which does not fit into the diagram. For instance, the lavas of the Lassens Peak district, comprising basalts, andesites, dacites, and rhyolites, form a rock series the composition of which may be represented by a well-defined diagram. The quartz-basalts, however, refuse to adapt themselves to the scheme. Their abnormal composition is clearly brought out by the plotting. In their content of lime and potash they do not differ notably from normal rocks of the same silica percentage, but they show a marked deficiency in alumina and ferric oxide and to a less degree in soda. **Magnesia and ferrous oxide are in excess.**

The plotting of analyses in the manner indicated by the author, and the interpretation of the diagrams thus made in the way outlined above, form a ready means of detecting rocks of abnormal composition in a set of normal rocks from the same petrographic province. The diagrams thus may be made a means of aiding rock classification, since they enable one to exclude from discussion those rock species which can have no part in any series of related rocks, and which if discussed together with normal rocks would give rise to difficulties hard to overcome in any scheme of classification. The author declares that a natural classification "must be based, confessedly or implicitly, upon fundamental genetic considerations, and primarily upon the mode of operation of the

processes of differentiation in rock magmas. Rocks resulting from admixture must therefore be excluded from the main scheme and be relegated to an appendix. Any discussion which tends to the recognition of this principle and to the establishment of some criterion of distinction will forward the object by disembarrassing the problem of a disturbing element."

The most recent and most complete discussion of the chemical elements of rocks is by Osann,[1] who proposes a formula for each rock which shall represent approximately its chemical composition and at the same time be capable of easy plotting. He also proposes a method of plotting by which the composition of a rock is indicated by the position of a dot in a triangular diagram. The dot in its relation to the bounding lines of the triangle exhibits at once the relative proportion of the important constituents in the rock mass. A single dot thus represents an entire rock. By plotting a large number of rocks on the same diagram their chemical relationships are easily and conveniently studied. The plotting at once exhibits a grouping of closely related rocks and differentiates those whose mineral composition may be similar but whose chemical composition is different. The personal element has no place in the system of plotting. The types are determined solely by the grouping of the dots which express by their position the composition of individual specimens. In the constructure of his rock formulas Osann transforms the percentage analyses into molecular proportions and recalculates to the sum of 100. The mean of two analyses of the norite[2] of Montrose Point on the Hudson River thus treated becomes

SiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O
59.50	10.35	7.38	.36	8.14	8.65	4.23	1.39

The percentage of SiO_2 (including ZrO_2 and TiO_2) in the recalculated analyses is represented by *S* with the corresponding exponent. By *A* is represented the alkalies in the molecular group $(NaK)_2Al_2O_4$. In the above instance $A = 5.62$. The lime is considered as in the group $CaAl_2O_4$ and is represented by *C*. But CaO may be present in another molecular group, whereas the Al_2O_3 occurs only in groups *A* and *C*. Hence $C = 10.35$ (molecular percentage of Al_2O_3 in analyses) minus 5.62 (the proportion of Al_2O_3 in group *A*) $= 4.73$. The remaining oxides are regarded as being present in the group (Fe, Mn, Mg, Sr, Ba, Ca)O, and this is represented by *F*, which

[1] *Tscher. Min. u. Petrog. Mitth.*, Bd. xix, p. 351.

[2] *Amer. Jour. Sci.*, vol. xxxiii (1887), p. 193.

measures the dark components of the rock mass. In the norite $F = 19.78$, *viz.*, $FeO = 7.38 + MnO = .36 + MgO = 8.15$, and the remainder of CaO left after subtracting 4.73 CaO (the amount necessary to combine with the 4.73% of Al_2O_4 in group *C*) from 8.65 CaO, the amount shown in the analysis. The relation of the alkalies to one another is indicated by the letter *n*, which is given a value corresponding to the proportion the Na_2O bears in the analysis to the total alkalies calculated to the unit 10. In the above analysis the Na_2O is to K_2O as 4.23 is to 1.39, or as 7.5 is to 2.5. *n* thus is 7.5. The formula of the rock is

$$S = 59.50, \quad A = 5.62, \quad C = 4.74, \quad F = 19.78, \quad n = 7.5.$$

In the plotting the absolute values of *A*, *C*, and *F* are not used, but instead their proportions are calculated to a total of 20 units, and these ratios are made use of. The values 5.62, 4.74, and 19.78 are as 4 : 3 : 13 in the scale of 20, and the simplified formula is $s_{59.5}, a_4, c_3, f_{13}, n_{7.5}$. This formula not only expresses the approximate chemical composition of the rock for which it is calculated, but it expresses also roughly the proportions of alkaline feldspars, lime feldspars, and dark components present in it, and from the formula may be calculated the analysis. The ratios $a : c : f$ are represented in a triangular projection by a dot, the position of which discloses at a glance the chemical character of the rock it represents. Rocks of similar composition are represented by groups of dots in certain portions of the triangle, and these groups are observed to fall naturally into subgroups. The discussion of these features is reserved by the author until after he has plotted the effusive rocks. The present paper deals exclusively with rocks possessing the granitic texture. Of these the author has investigated over 200. He has recalculated the proportions of each of the analyses and has plotted them in a series of projections. A final projection contains all the types and thus serves as a summary of the work. Among the rock analyses studied, 40 are of granites, 36 of syenites, 37 of diorites, 28 of eleolite-syenite, 27 of gabbros, 23 of essexites and theralites, 4 of iolites and other rare basic rocks, and 11 of peridotites.

Moses and Parsons,[1] Elements of Mineralogy, Crystallography, and Blowpipe Analysis, etc. — The new edition of Moses and Parsons's *Elements of Mineralogy* covers concisely the greater part of the field of mineralogy. As its title indicates, it not only treats

[1] Moses, A. J., and Parsons, C. L. *Elements of Mineralogy, Crystallography, and Blowpipe Analysis*, from a practical standpoint, including a description of all

of the descriptive portion of the science, but it is also a very brief but quite satisfactory treatise on blowpipe analysis. It contains also a discussion of crystallography and a summary of the principles of physical mineralogy. That the authors have attempted to cover too much ground in the volume might be judged from this summary of its contents. Everything discussed, however, is so concisely put that the parts of the book are fairly well proportioned. The chapters on the optical, thermal, and electrical properties of minerals are so brief that they possess little value. But since these properties are those of least importance to a class of students beginning the study of the science, perhaps this fault is not of practical moment.

In the opinion of the writer the discussions are throughout the book so compactly condensed that it cannot be used successfully as a text-book. There are too many points in it that need amplification. As an accompaniment to a course of lectures on mineralogy, however, it seems to be very well suited. Indeed, it is an excellent book for use in this way. The volume is not as large as Dana's *Text-Book of Mineralogy*, and therefore is better suited to courses extending through half a year; and yet, at the same time, it is not as small in size nor as elementary in the treatment of its subject-matter as are most of the *Elementary Mineralogies* on the market, most of which are entirely without value for class-room purposes.

The changes noted in the new edition as compared with the old one are: the treatment of crystallography according to the newly accepted classification of crystal forms, the addition of about one hundred figures illustrating the combination of forms observed on definite mineral species, the revision of the chapters relating to blowpipe analysis, the addition of a description of the spectroscope and its use, the complete revision of the paragraphs dealing with the economic uses of the different minerals and the simplification of the part devoted to determinative mineralogy.

The book is well printed on good paper. The figures illustrating crystals are for the most part beautifully clear, but most of the woodcuts supposed to represent the appearance of minerals as they actually occur in nature are poor. They might well be omitted without affecting the value of the book a mite.

W. S. B.

common or useful minerals, the tests necessary for their identification, the recognition and measurement of their crystals, and a concise statement of their uses in the arts. New enlarged edition. New York, D. van Nostrand Company, 1900. 413 pp., 664 figs.

Kemp's Handbook of Rocks, for use without the Microscope, Second Edition.[1] — The publication of a new edition of the *Handbook of Rocks* so soon after the appearance of the first edition is a guarantee that the author has furnished a book that has given satisfaction to its users. It is the only treatise in English that aims to give the student an accurate and scientific knowledge of rock-masses without requiring him to master the technique of microscopical analysis. The new edition differs from the earlier edition principally in the glossary, which has been extended to include the new terms proposed by petrographers in the discussions of the past four years. The volume is of handy size and is beautifully printed on excellent paper.

Hovelacque's Photographs of Sedimentary Rocks.[2] — This album consists of sixty-nine plates, presenting microphotographs of thin sections of alpine limestones. These photographs were made in the course of a full investigation of the so-called "Calcaires du Briançonnais," in the French Alps, by Messrs. Killian and Hovelacque, who hoped by means of microscopic study to be able to determine more accurately the various horizons of the series in the absence of available fossils. The work was interrupted by the untimely death of Mr. Hovelacque, and this album is a preliminary report presenting his uncompleted work.

The plates represent a great variety of limestone structures, as well as many types of the minute organisms which compose, in large part, many of the limestones. Full explanations make each plate intelligible, and together they make a valuable addition to our knowledge of the microscopic petrography of the sedimentary rocks whose value will, however, be much enhanced when the fuller report, which is promised by M. Killian, makes its appearance.

[1] Kemp, J. F. *A Handbook of Rocks, for use without the Microscope.* With a glossary of the names of rocks and of other lithological terms. Second edition, revised. New York, D. van Nostrand Company, 1900. 185 pp.

[2] Killian, W. *Album de Microphotographies de Roches Sédimentaires faites par Maurice Hovelacque.* Paris, Gauthier-Villars, 1900. 14 pp., quarto, 69 plates.

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A THEORY OF THE ORIGIN AND EVOLUTION OF THE AUSTRALIAN MARSUPIALIA.

B. ARTHUR BENSLEY.

INTRODUCTION.

ALTHOUGH considerable attention has been given to the discussion of the family and generic affinities of the Australian marsupials from a systematic standpoint, until very recently the phylogenetic aspects of the question have been generally neglected. On this account, and also from the fact that little information has been forthcoming either from paleontology or geographical distribution, it has not been possible, up to the present time, to form an adequate conception of the origin of the fauna and its phylogenetic relationships.

The present paper is the result of an attempt to outline a plan of evolution for the group by comparing the adaptive modifications of the teeth and feet with those of placental mammals, in which the course of evolution is fairly well known. On account of the difficulties with which the writer has had to contend in having only a small number of marsupial types at his disposal, the present plan is advanced simply as a working

hypothesis. A fuller discussion of the question will be published in the course of a few months.

The fact was noticed long ago by Cuvier, and has been commented upon by many zoölogists since, that the marsupials of Australia assume much the same rôles in nature as are taken by placentals in other parts of the world, and that they show extensive resemblances to the latter in many features of their external organization. It is only within the last few years, however, in fact since the evolution of the placentals has come to be understood, that the exact significance of these resemblances has been at all apparent. Knowing that during the Tertiary period placental mammals have undergone a progressive development, or, in other words, an adaptive radiation, from diffuse or collective types, by which not only their minor but also their ordinal characters have been established, the question now suggests itself, Have not the Australian marsupials undergone an entirely similar or, in other words, a *parallel* radiation?

The possibility of such a condition has already been suggested by Osborn ('99a), who recognizes several mammalian radiations, including among them a marsupial radiation for Australia, and remarks as follows: "We mark the fact that the above radiations are all of ordinal rank, for the marsupial radii, although termed families, are adaptively equivalent to several placental orders."

Examining the composition of the group somewhat in detail, we find many indications of such a parallel radiation. Two classes of facts may be specially noticed in this connection. First, the Australian marsupials constitute a very homogeneous group; although differing widely in extremes, not only the various genera of a family but also the families themselves are connected by almost insensible gradations of structure. Second, the adaptive modifications of their teeth and feet are very similar to those of placental mammals either at the present day or during their progressive development in the Tertiary period, and they bear the same relation as do those of placentals to the general primitiveness of the animals in which they occur.

The Australian marsupials, therefore, show no signs of a

composite structure such as might be expected if they represented migrated portions of the fauna of another continent, or, again, if they were of polyphyletic origin. Except in a very few instances, they show no signs of degeneration; as a group they are, like the placentals, progressive throughout. In short, the only satisfactory explanation that can be given for the homogeneous character of the group and their adaptive resemblances to placentals seems to be that they have undergone an entirely similar radiation under similar conditions, that it has proceeded from a single sharply marked ancestral type, and that the center of radiation has been the Australian region itself.

Assuming that a similar radiation has taken place in marsupials and placentals, it will be apparent that a plan of evolution may be constructed for the former by inference from that of the latter. Thus, by noting the sequence of events in the development of the adaptive modifications of the teeth and feet in placentals during the Tertiary period, we may infer a similar sequence in those of marsupials, and in this way determine their probable course of evolution in these structures, and also the characters of their stem form.

The Probable Characters of the Marsupial Stem Form.

Dentition. — In the case of the placental mammals, progressive evolution in dentition is accompanied by a reduction of certain of the teeth and by an elaboration of certain others, notably the molars. Unreduced dentitions with slightly elaborated teeth are therefore primitive. But just as in formulating such a law it is necessary to exclude those forms whose dentition, while being of primitive aspect, is not typically primitive, but primitive through degenerate specialization (Delphinidæ, Otariidæ), it is also necessary in applying it to the case of the marsupials to exclude similarly conditioned forms of that series.

The only marsupials which call for consideration in this respect are the forms Myrmecobius and Notoryctes.[1] There

[1] Tarsipes appears to be degenerate in dentition, but the teeth are not primitive in aspect.

are two reasons for regarding these as degenerate in dentition. First, there is a prototypal tooth pattern in marsupials, which is shared alike by the Didelphyidæ and the insectivorous members of the Dasyuridæ, and of which the tooth patterns of the carnivorous Dasyuridæ and the Peramelidæ are undoubtedly progressive modifications, while those of Myrmecobius and Notoryctes are aberrant. The tooth patterns of both of these forms are more primitive in aspect than those of any other of the Australian forms, but the animals are specialized in other respects. Thus Myrmecobius is typically dasyurid in foot structure and in its incisor formula of $\frac{4}{3}$, while Notoryctes, according to Dollo ('99), is specialized in a phalangerine direction in foot structure. Second, both Myrmecobius and Notoryctes are ant-eating forms,[1] such animals being usually degenerate in dentition, judging from Echidna and the placental Myrmecophagidæ and Manidæ, in which the teeth have been entirely lost.

Excluding Myrmecobius and Notoryctes, we find the primitive dental characters of marsupials distributed as follows :

The least reduced dentition is found in the Peramelidæ, where the formula is : $i.\frac{5}{3}$, $c.\frac{1}{1}$, $p.\frac{3}{3}$, $m.\frac{4}{4}$.[2]

The least elaborated molar teeth are found in the insectivorous members of the Dasyuridæ. The upper teeth (Pl. I, Fig. *d*)[3] are triangular in shape, with three main cusps (protocone, paracone, metacone)[4] and an outer row of styles. There are no conules at the base of the protocone, such as are commonly met with in placental types. The metacone exceeds the paracone in size, and its posterior border is produced into a trenchant spur. The lower teeth (Pl. II, Fig. *d*) are of the

[1] For habits of Notoryctes see Stirling ('91, p. 158) and Spencer ('96, p. 50, Mammalia).

[2] Or $(m)i.\frac{5}{3}$, $mc.\frac{1}{1}$, $mp.$ and $pp.\frac{4}{4}$, $m.\frac{3}{3}$, following Lydekker ('99). The upper incisor dentition may contain teeth of both series.

[3] This type might be more appropriately illustrated by the teeth of Phascologale, Sminthopsis, or Antechinomys, *Dasyurus viverrinus* being more carnivorous in habit. Thomas, however, remarks that the teeth of the three former genera resemble one another very closely, and differ only from those of Dasyurus in being more acutely cuspidate. See Thomas ('88, pp. 273, 298, 309).

[4] Following the nomenclature of the tritubercular theory. See Osborn ('88, '91).

tubercular sectorial pattern, with a main triangle bearing three cusps (protoconid, paraconid, metaconid) and an antero-external shelf, and a posterior heel bearing one outer (hypoconid) and two inner (entoconid and hypoconulid) cusps.

Foot Structure.[1] — In placental mammals, progressive evolution in foot structure, beautifully illustrated in Tertiary Ungulata, is accompanied by a reduction of certain of the digits, and by an elaboration of certain others, the evolution proceeding from an ideal pentadactyl condition, such as is seen typically in the Eocene Creodonta. Among the Australian marsupials the nearest approach to the ideal pentadactyl type is seen in certain members of the Dasyuridæ (Pl. III, Fig. *d*). The hallux is opposable but slightly reduced, while the remaining digits are normal.

Summing up the above results, we may make the general statement that the marsupial stem form possessed the following characters, or more primitive ones: Dental formula, $i.\frac{3}{3}, c.\frac{1}{1}, p.\frac{3}{3}, m.\frac{4}{4}$. Upper molar teeth triangular, with three main cusps and an outer row of styles; metacone exceeding paracone, its posterior border produced into a trenchant spur; no conules at the base of the protocone. Lower teeth with anterior triangle bearing three cusps and an antero-external shelf, and posterior heel bearing one outer and two inner cusps. Foot with hallux completely opposable, the remaining digits normal.

The fact will now be apparent that the above prototypal characters are not found associated in any Australian form. All of the Australian marsupials are derived types. On the other hand, with one exception they are all found in the American Didelphyidæ. The one exception refers to the presence in the latter of four instead of three lower incisors, and in this respect the Didelphyidæ are more primitive. The molar tooth patterns of the stem form are almost exactly reproduced in those of the Oligocene Opossums (Peratherium) (Pls. I and II, Fig. *a*).[2]

[1] This refers throughout to the pes in the case of the marsupials.

[2] In the specimen from which these diagrams were taken (*Peratherium fugax* Cope) the outer parts of the upper molars are worn, so that, although there is a conspicuous external ridge, the presence of styles cannot be affirmed. *Cf.* Cope ('84, Pl. LXII, Fig. 2*a*).

As regards the modifications of the teeth and feet, therefore, the Didelphyidæ exhibit characters which are ancestral to those of the Australian marsupials. The question now arises as to whether or not they are ancestral in other respects. The opportunity has not yet presented itself to the writer of examining the case in detail, so that only a few examples will be given here. As was pointed out in 1880 by Brass, the complex modifications which result in the formation of the peculiar median vagina in specialized marsupials are seen in their incipient stages in the Didelphyidæ, where the two vaginæ bend toward one another in the middle line. Passing onwards from the Didelphyidæ every gradation is met with, until the final stage is reached in the Macropodidæ.

Again, taking the case of the marsupium, the anteriorly directed opening of this structure, as seen in the Phalangeridæ and Macropodidæ, and the posteriorly directed opening, as seen in the Peramelidæ and Notoryctidæ, are obvious departures from such a type as is seen in the Didelphyidæ and Dasyuridæ, in which the opening is directed vertically downwards.

Finally, taking the case of the tail, which is an adaptive structure of the greatest importance in marsupials, it is entirely probable that the hairy, non-prehensile condition, where it occurs in the Australian forms, has been derived from a naked, scaly, prehensile one, such as is seen in the Didelphyidæ. Thomas ('88) describes for the Dasyuridæ, in which the tail is hairy and never prehensile, a scaly condition in various genera, among them *Phascologale wallacei*, *P. flavipes*, and *Sminthopsis leucopus*. A scaly tail, which, according to Thomas, is said to be also prehensile, is found in *Perameles broadbenti* among the Peramelidæ. Every grade of prehensilism is met with among the Phalangeridæ; and, finally, among the Macropodidæ, a scaly tail is found in *Hypsiprymnodon moschatus*, and a prehensile one in the various species of Bettongia.

The above facts, when added to the evidence of the teeth and feet, suggest strongly a former connection of the Didelphyidæ with the Australian marsupials, and although, in attempting to express such a connection phylogenetically, it is a natural procedure to regard the original members of each

group as the descendants of a common stock, the Didelphyidæ are so primitive that it is scarcely possible to regard them, as a family, otherwise than ancestral.[1]

The Evolution of the Teeth in Australian Marsupials.

It has already been mentioned that progressive evolution in dentition, in the case of the placental mammals, is accompanied by a reduction of certain of the teeth and by an elaboration of certain others, notably the molars. The researches of Cope, Osborn, and others have shown that in the evolution of the molar teeth the elaboration proceeds from a trituberculate condition in the upper series, and from a quinquetuberculate or sexituberculate condition in the lower series. These types are exemplified in the teeth of the primitive Creodonta of the early Eocene (Protochriacus, Oxyclænus, etc.).

[1] This involves the question of the limitations of the family Didelphyidæ. Lydekker ('**96**, p. 109), while assigning the didelphyid incisor formula to the ancestors of the Dasyuridæ, speaks (p. 55) of the Didelphyidæ and Dasyuridæ as descendants of a common stock. Spencer ('**96**, p. 188, Summary) speaks of a primitive (South American) group giving rise to the Didelphyidæ of America on the one hand, and to the early Australian types on the other. Ameghino ('**93**, p. 16) regards the family called by him Microbiotheriidæ as ancestral to the Didelphyidæ and to the Australian Dasyuridæ. In the writer's opinion it will not be found advisable ultimately to regard the Didelphyidæ as a modern derived group, but that, when the actual ancestors of the Australian forms are identified, it will probably be found necessary to extend the family Didelphyidæ to include them. Two reasons for this view may be noted. First, the Oligocene forms of Europe and North America have already been included in the existing American family; in other words, we identify as Didelphyidæ forms which existed at about the time when the Australian fauna probably arose. Second, the family Didelphyidæ, as at present limited, is not equivalent to any one of the four typical families of Australian marsupials, the latter being much more comprehensive. The diversity of organization which is met with among the Dasyuridæ in the genera Phascologale and Thylacinus, among the Phalangeridæ in the genera Phalanger, Phascolarctos, and Tarsipes, among the Macropodidæ in the genera Hypsiprymnodon and Macropus, is absolutely without parallel among the Didelphyidæ. If, therefore, the integrity of the Australian families is to be retained, — and there is every reason for believing that they are natural groups, — there are good grounds for extending the family Didelphyidæ to include their own ancestors and those of the Australian forms, if the latter, as they probably did, possessed the main didelphyid modifications of the teeth and feet, even while differing in other minor details. The Microbiotheriidæ of Ameghino may be a case in point.

From this point onwards development takes place along two main lines. In one case the outer cusps of the teeth from being tuberculate become laterally compressed and trenchant, giving rise to the carnivorous modification, seen typically in the specialized Creodonta (Oxyæna, Hyænodon, Oxyænodon, etc.). In the other case the primitive tooth pattern is entirely changed; the upper teeth become quadritubercular by the addition of a postero-internal cusp (hypocone), while the lower teeth also become quadritubercular by the reduction of the most anteriorly placed cusp (paraconid), and the intermediate cusp of the heel (hypoconulid). In this way a primarily omnivorous modification is instituted, which is seen in its constructive stages in the Eocene Condylarthra (series Protogonodon, Euprotogonia, Phenacodus, and various separate genera).

From the typically quadrituberculate condition evolution proceeds in two directions, both leading to the herbivorous modifications of the Ungulata. In one series the cusps of both upper and lower teeth become crescentic, producing the condition characteristic of the Artiodactyla; while in the other they become lophoid, producing the complex modifications of the Perissodactyla. The latter evolution is beautifully illustrated in passing from the Eocene genera (Hyracotherium, Systemodon, etc.) to the modern types.

If, now, we arrange the teeth of the Australian marsupials according to the above placental plan, we obtain such a result as is represented diagrammatically in Pls. I and II. The primitive trituberculate, tubercular sectorial type is here represented by the teeth of *Dasyurus viverrinus* (Fig. *d*). As indicated elsewhere in a footnote, this would be more appropriately illustrated by the teeth of one of the purely insectivorous forms of the Dasyuridæ (Sminthopsis, Antechinomys, Phascologale).

The carnivorous line above mentioned is, in the case of the Australian marsupials, entirely confined to the family Dasyuridæ, and it culminates in the Tasmanian wolf (*Thylacinus cynocephalus*). The teeth of this animal are represented in Pls. I and II, Fig. *g;* they show all the essential characters of those of Dasyurus, except that in the lower teeth the metaconid is absent. The progressive carnivorous modification is, in the

upper molars, a conversion of the paracone and metacone into cutting blades, and a reduction of the outer styles, which are here represented by very inconspicuous tubercles. In the lower teeth the progressive modification is a conversion of the paraconid, protoconid, and hypoconid into cutting blades, and a reduction of the metaconid, hypoconulid, and entoconid.

Turning to the second stem, leading to the omnivorous and herbivorous modifications, we find the first stage represented in the teeth of the Peramelidæ. The upper molars of *Perameles nasuta* (Pl. I, Fig. *e*) show all the essential characters of those of Dasyurus, but in addition they show an incipient hypocone. In the third molar the hypocone is not very pronounced, and the tooth is triangular; but in the second molar the hypocone is well developed, and the tooth is now quadrate. Thomas ('88, p. 220) describes the triangular and quadrate modifications as characteristic of the family. The upper molars of the Peramelidæ parallel, in a general way, those of the Condylarthra above mentioned. The lower molars of *Perameles nasuta* (Pl. II, Fig. *e*) resemble still more closely those of Dasyurus, the omnivorous modification being only apparent in the posterior heel, where the hypoconulid is reduced.

The completed omnivorous modification is doubtless to be met with in the Phalangeridæ. Unfortunately, only two examples of this family have been available to the writer, namely, *Trichosurus vulpecula*, which is highly specialized, and *Petauroides volans*. The teeth of the latter animal are represented in Pls. I and II, Fig. *f*. Although they illustrate the completed quadrituberculate condition, they are only approximately transitional; the hypocone is completely formed in the upper molars, and the paraconid is reduced in the lower molars; but the antero-external shelf, which is prominent in the lower teeth of the Peramelidæ and Dasyuridæ and very conspicuous in those of the Macropodidæ (Pl. II, Fig. *i*), is here absent, and there are no traces of external styles in the upper teeth.

The selenoid modification of the cusps, which is so widely represented in the artiodactyl Ungulata, appears to be confined to the single form Phascolarctos (Pls. I and II, Fig. *j*) among the marsupials, but the lophoid modification is widely represented

in the Macropodidæ (Pls. I and II, Fig. *i*). The incipient stages are seen in the teeth of the specialized Phalanger, *Trichosurus vulpecula* (Pls. I and II, Fig. *h*), and also in those of *Hypsiprymnodon moschatus* (Macropodidæ). It is of interest to note that the lophoid modification is accompanied by a hypsodont condition of the crown in the Macropodidæ, as in the perissodactyl Ungulata.

THE EVOLUTION OF THE FEET IN AUSTRALIAN MARSUPIALS.

It was pointed out by Huxley in 1880 that none of the Australian marsupials possess a normal pentadactyl pes, that wherever the hallux is present it presents an extensive movement of adduction and abduction; in other words, that the marsupial foot is typically prehensile.

Quite recently a careful study of the foot structure of marsupials has been made by Dollo ('99), who endeavors to demonstrate a derivation of all recent forms from arboreal ancestors. Dollo has indicated all the important adaptive modifications in Australian marsupials, although he has not discussed their phylogenetic significance, so that all that is necessary in the present paper is to arrange his types into a phylogenetic series, in accordance with his interpretations and the general plan noted above for the placentals.

Dollo has shown that the arboreal marsupials present successive stages of arboreal adaptation, following which the foot becomes more and more modified. Thus, beginning with the Didelphyidæ (Pl. III, Fig. *a*), the foot is provided with an opposable hallux, and the remaining digits are normal. In the Phalangeridæ (Fig. *b*) the hallux is again opposable, but in addition the fourth digit is enlarged, and the second and third are reduced and syndactylous. Finally, in one member of the Phalangeridæ, Tarsipes (Fig. *c*), there is, in addition to all of these arboreal characters, a recession of the claws of the fourth and fifth digits. It is thus possible to recognize an arboreal line of evolution such as is represented in Pl. III, *a–c*.

Among the terrestrial or semi-terrestrial marsupials, all of the forms, except the specialized members of the Dasyuridæ,

show some of these arboreal characters, indicating that up to a certain stage they have been arboreal in habit. It is thus a simple matter to arrange them in collateral groups according to the stage at which their terrestrial evolution began. Such an arrangement as this is represented diagrammatically in Pl. III, in the side lines passing off from the main arboreal line *a–c*. The first series to be given off is that of the Dasyuridæ. In the least modified members of this family the animals are still arboreal, and the foot (Fig. *d*) is like that of Didelphys (Fig. *a*), except that the hallux is slightly reduced. As Dollo has pointed out, it is possible to recognize a complete series here, following which the hallux becomes gradually reduced and finally obliterated (*e*).

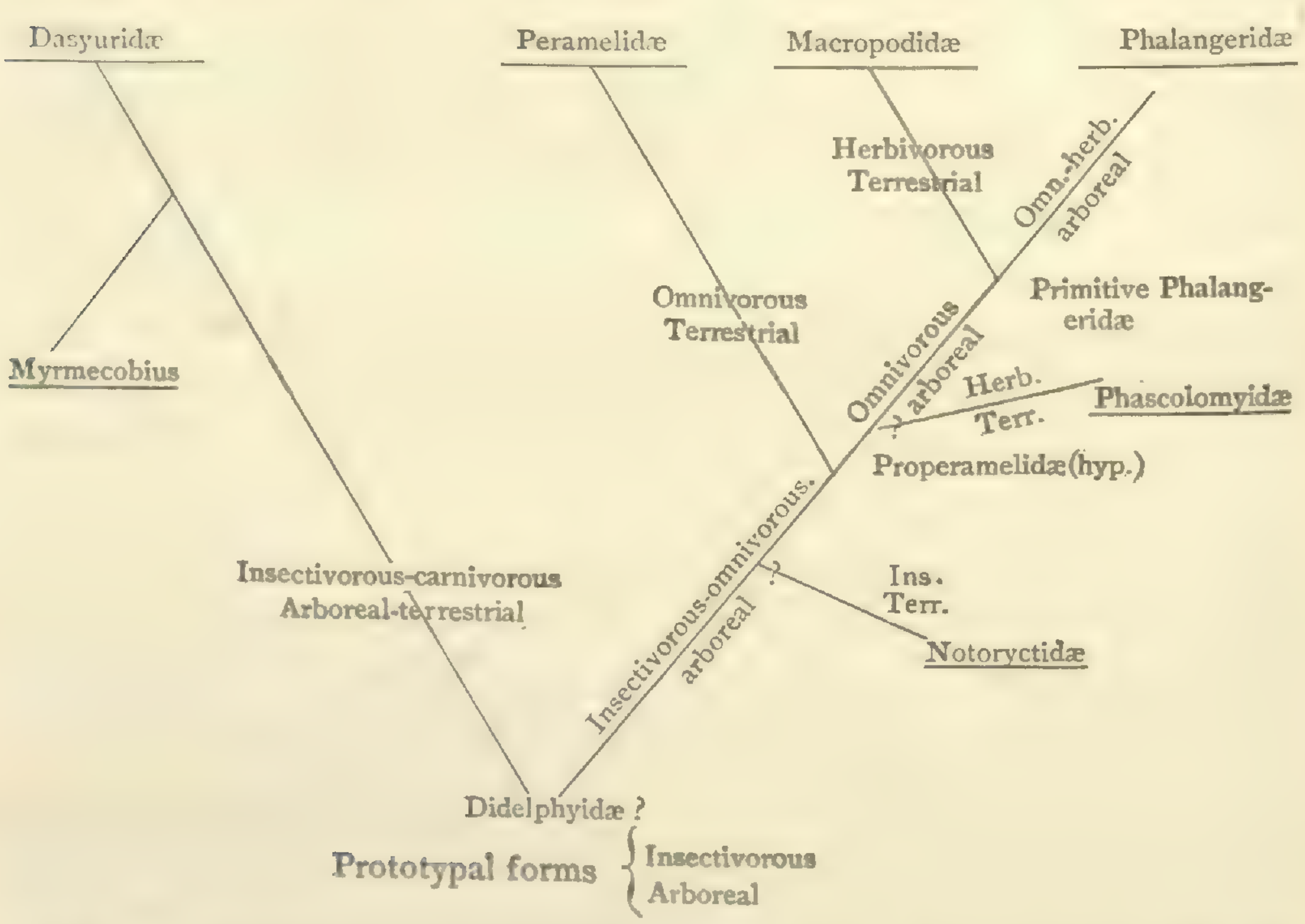
Two other terrestrial offshoots, which parallel one another, and arise from the main arboreal line at the phalangerine stage, are represented by the Peramelidæ and Macropodidæ. In both of these the evolution is cursorial as well as terrestrial, and is accompanied by a reduction of the hallux and an enormous enlargement of the fourth digit, so that the foot becomes functionally monodactyl. The extremes of structure in these lines are, as Dollo has indicated, in the Peramelidæ *Perameles doreyana* (Fig. *g*) and *Peragale leucura* (Fig. *h*) and in the Macropodidæ *Hypsiprymnodon moschatus* (Fig. *i*) and Macropus (Fig. *j*).

Another terrestrial offshoot is represented by the Phascolomyidæ (Fig. *f*), although the relations of this branch are doubtful. The hallux is reduced in these animals as in other terrestrial forms. With respect to the remaining digits, the foot appears to be transitional between that of the Didelphyidæ and that of the Phalangeridæ, the second and third digits not being so reduced as in the latter family. The difficulty arises here as to whether or not the second and third digits, from being fully reduced, as in the Phalangeridæ, have been secondarily enlarged. Such a condition would appear to be not improbable in slow-moving animals, such as the wombats; in the other animals which have passed through a phalangerine stage the tendency towards monodactylism has doubtless prevented the second and third digits from becoming secondarily functional.

For Notoryctes Dollo describes a slight syndactylism and reduction of the second and third digits, which points out this form as still another offshoot of the main arboreal line.

GENERAL REMARKS ON THE EVOLUTION OF AUSTRALIAN MARSUPIALS.

When we compare the plan of evolution as determined by the structure of the teeth with that determined by the structure of the feet, we note the fact that they practically coincide. Thus there are two lines leading from the prototypal forms, one of them showing an insectivorous-carnivorous and an arboreal-terrestrial evolution leading to the Dasyuridæ, the other showing an insectivorous-omnivorous and a progressive arboreal evolution leading to all the remaining marsupial families.



Following the former line, there appears to have been a typical evolution in all forms except Myrmecobius, which, as noted above, is probably degenerate in dentition.

Following the omnivorous arboreal line, we find that one of its stages has been obliterated, being unrepresented among existing forms. The characters of other forms, however, leave

no doubt as to its composition. Thus the Phalangeridæ present a typical arboreal modification of the foot, combined with advanced omnivorous and herbivorous modifications of the teeth, while the Peramelidæ present a terrestrial modification of the phalangerine foot, combined with a primitive omnivorous condition of the teeth. There must, therefore, have existed at some time, if the present plan is reliable, a series of forms such as is represented in the general diagram on p. 256 as Properamelidæ (hyp.), consisting of animals which combined a phalangerine type of foot with a primitive omnivorous dentition. These animals would have given rise to the Peramelidæ by a terrestrial modification of the foot, and to the Phalangeridæ by a more completely omnivorous and finally herbivorous modification of the teeth.

From the phalangerine stem, after the omnivorous modification was established, there was apparently given off a branch to the Macropodidæ, with a trend of evolution from arboreal to terrestrial, and from omnivorous to herbivorous. The herbivorous modification reaches its greatest development in this family.

The phylogenetic positions of the Phascolomyidæ and Notoryctidæ, as indicated in the general plan, are by no means certain. In the case of the former, the difficulty in interpreting the foot structure has already been commented upon. The unworn molar teeth of these animals are said by Krefft ('75) to be quadrituberculate. If such is the case, it would appear probable that they arose from the omnivorous arboreal stem after the Peramelidæ were given off, and that there has been a secondary enlargement of the second and third digits.

In the case of the Notoryctidæ the writer has not been able as yet to decide definitely the cusp homologies in the upper teeth, but the lower are undoubtedly tritubercular; as indicated above, the dentition is probably degenerate. Combining this interpretation with the evidence of arboreal characters in the foot, it would seem probable that Notoryctes arose from the arboreal omnivorous line somewhere near the Properamelidæ.

A DIDELPHYID ORIGIN IN THE LIGHT OF GEOGRAPHICAL DISTRIBUTION.

In discussing the question of the origin of the Australian marsupials it is apparent that, apart from the evidence derivable from the organization of existing types, any opinions which are expressed on the subject must take into consideration the present and past geographical distribution of marsupials, the manner in which the ancestral forms gained access to the Australian region, and the time at which their entry was effected.

Within the last twenty-five years several attempts have been made to connect the Australian marsupials with the extinct types of different horizons in other countries, and to explain in this way the conditions of their origin. Thus, in 1876, Wallace suggested a possible relation to the Jurassic forms of the northern hemisphere.[1] Concerning this he speaks as follows: "As, however, no other form but that of the Didelphyidæ occurs there (in Europe) during the Tertiary period, we must suppose that it was at a far more remote epoch that the ancestral forms of all the other marsupials entered Australia; and the curious little mammals of the Oölite and Trias offer valuable indications as to the time when this really took place."[2] . . . "It was probably far back in the Secondary period that some portion of the Australian region was in actual connection with the northern continent; and became stocked with the ancestral forms of marsupials."[3]

In 1882 Cope, in commenting upon the ancestry of Thylacoleo, placed this form in the family Plagiaulacidæ of the northern hemisphere, and regarded the latter as related to the Australian Macropodidæ through a hypothetical ancestor Tritomodon. There is, however, no valid evidence in favor of this view.

[1] Haeckel has recently endeavored to express such a relation phylogenetically by deriving all of the modern marsupials from a Jurassic group of Prodidelphia, which he regards as also ancestral through certain of its members, the Amphitherida and Amblotherida, to the placentals. See Haeckel ('**95**, p. 471).

[2] Wallace ('**76**, vol. ii, p. 253).

[3] *Ibid.* (vol. i, p. 465).

By far the most complete discussion of the question, from all points of view, is that given by Lydekker ('96) in his *Geographical History of Mammals*. Lydekker, while agreeing with Wallace as to the northern origin of the Australian fauna, fixes its time of entry at a much later period, namely, at the beginning of the Eocene, on the basis of a possible connection of the ancestors of the Australian Dasyuridæ with those of the Oligocene Didelphyidæ of the northern hemisphere. He remarks as follows (p. 55): "Recent researches have tended to show that the alliance between the Dasyuridæ and the Didelphyidæ is much more intimate than was formerly supposed to be the case. This being so, it is a fairly safe assumption that both families are descended from a single common ancestral stock." . . . "Not improbably polyprotodont marsupials survived in southeastern Asia till the early portion of the Eocene division of the Tertiary epoch, and in this region both Dasyuridæ and Didelphyidæ were differentiated. Representatives of the former family soon afterwards found their way into Australia and New Guinea, while the opossums would appear to have dispersed in one direction into Europe and in the other into North America."

Objection has been taken to this view by Spencer ('96) on account of the difficulty of explaining by it the non-appearance of Didelphyidæ in Australia and the paucity of polyprotodont types in New Guinea, and also on account of the lack of evidence of the former presence of marsupials in Asia.

For a northern origin Spencer substitutes a South-American one taking place in the late Cretaceous through the medium of an Antarctic continent. This idea is also favored by P. L. and W. L. Sclater ('99). Viewing the question from a phylogenetic standpoint alone, Lydekker has recently ('99) suggested the Prothylacinidæ (Sparassodonta of Ameghino) of the South-American Miocene as possibly ancestral to the Dasyuridæ, and Ameghino ('93) regards the family called by him Microbiotheriidæ as ancestral to both the Dasyuridæ and the Didelphyidæ.

Spencer, however, in attempting to derive the Australian fauna, encounters the same difficulty which confronted Lydekker, namely, how to explain the non-appearance of Didelphyidæ

in Australia. Concerning this he remarks as follows (p. 188, Summary): "The only way in which it seems possible to account at once for the presence of forms such as Prothylacinus in the Patagonian Tertiary beds, and the absence of any of the Didelphyidæ in Australia, is to suppose that on the South-American side the connection between the Antarctic land and what is now Patagonia was lost at a time comparatively soon after the early polyprotodonts had passed across, and during which the Didelphyidæ were being developed perhaps in the more northern part of South America."

In the writer's opinion, the difficulty of explaining the absence of the Didelphyidæ from Australia is only an apparent one, which is due to the interpretation of this family as a modern derived group. Reasons have already been given for the elevation of the family to an ancestral position, and if the case is susceptible of proof, no other explanation is necessary to account for their absence from the Australian region than the assumption that they were formerly present and subsequently disappeared. If we imagine the family to have originally gained access to the region, it is not difficult to conceive that, in establishing the foundations of an extremely comprehensive adaptive radiation, especially under the favorable conditions of absolute freedom from competition, they should have thrown aside their distinctive didelphyid characters. And more especially is this conceivable when we realize that the differences of structure separating the Didelphyidæ from the most primitive of the Australian forms (insectivorous Dasyuridæ) are very slight.[1]

Concerning the direction from which the ancestral Didelphyidæ may have entered the Australian region, there is at least some justification for the view that it was from the northward. Lydekker ('96, p. 57) has called attention to the fact that there are marked indications of a faunal affinity of North America and Asia, which points to an interchange of forms between the two continents. This suggests a connection of the Oligocene opossums of Europe with those of North America, and, as Lydekker has pointed out, there may have

[1] *Cf.* Thomas ('88, p. 315).

been a migration of these animals into both countries from a common center in Asia ; on the other hand, there may have been simply a passage of forms *via* Asia. In either case the former presence of opossums on the latter continent would be indicated.

However this may be, the actual evidence at our disposal is very slight, and it is equally conceivable that ancestral Didelphyidæ may have entered by way of Antarctica. This possibility has been suggested by Osborn ('**99b**), although no preference is indicated by him for either view. As already indicated, the time at which the ancestral marsupials gained access to the Australian region has been estimated by Wallace as "far back in the Secondary," by Spencer as Cretaceous, and by Lydekker as early Eocene. It is probable, however, that these estimates are much too great, and that the time of entry was considerably later. Comparing the marsupial and placental radiations with respect to the modifications of the teeth and feet, we notice the fact that while there is a general correspondence between the most primitive characters of each series, there is no such correspondence between the most specialized ones. The most specialized characters of marsupials are decidedly primitive as compared with the most specialized characters of placentals. To illustrate the case, while the insectivorous members of the Dasyuridæ and the Didelphyidæ approach closely the trituberculate pentadactyl ancestors of the placentals, the Macropodidæ, which are the most specialized of the marsupials, are much more primitive than the most specialized placentals (perissodactyl Ungulata) whose evolution they parallel. The lophiodont teeth of these forms are very similar to those of such persistent primitive types as the Tapiridæ and their immediate ancestors, having none of the complex characters of those of the progressive lophiodont forms (Equidæ and Rhinocerotidæ). The functionally monodactyl, cursorial feet of the Macropodidæ are primitive as compared with the similarly modified feet of the Equidæ. Further, there is the remarkable fact that while the marsupial families have the value of placental orders, it is barely possible to separate them

sharply as families. In fact, they show such a composition as must have existed at some stage of the placental radiation.

Now the Macropodidæ show no signs of being persistent primitive types, and there seems to be no valid reason for assigning to the marsupials a different potential of evolution. The only explanation which may be given for the above facts is, therefore, that the Australian radiation has been of comparatively short duration.[1] And if the placental radiation began in the late Cretaceous or in the early Eocene, as now appears probable, it is unlikely that the marsupial radiation can have begun until well on into the Tertiary. An ancestral association with the Oligocene opossums of the North or even with the Lower Miocene forms of South America is thus not improbable.

As to whether or not the ancestral forms gained access to the Australian region by means of a land connection would appear to be a matter of little consequence if the fauna is of didelphyid origin. Such minute animals as they must have been, judging from the Oligocene forms of the northern hemisphere and the diminutive opossums of South America, might have gained access to the region by transportation in various ways.

In conclusion, the writer wishes to acknowledge his indebtedness to Professor H. F. Osborn of Columbia University for many kind suggestions during the preparation of this paper, and to Professor Allen of the American Museum of Natural History, New York, Professor W. B. Scott of Princeton University, and Professor R. Ramsay Wright of the University of Toronto, for the privilege of examining the marsupial collections of the above-named places.

COLUMBIA UNIVERSITY, NEW YORK.

[1] This suggests Huxley's statement of twenty years ago: "And I suspect that most, if not all, of the Australian forms are of comparatively late origin." (On the Application of the Laws of Evolution, etc., *P. Z. S.* (1880), p. 656).

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EXPLANATION OF PLATE I.

Illustrating the patterns of the upper molar teeth in marsupials and their probable phylogenetic relations.

NOTE. — The prototypal form is provisionally represented by Peratherium. Figs. b and c are inserted for comparison.

a. — *Peratherium fugax* Cope.
b. — *Didelphys azaræ* Temm.
c. — *Didelphys virginiana* Kerr.
d. — *Dasyurus viverrinus* Shaw.
e. — *Perameles nasuta* Geoff.
f. — *Petauroides volans* Thos.
g. — *Thylacinus cynocephalus* Fisch.
h. — *Trichosurus vulpecula* Jent.
i. — *Macropus sp.*
j. — *Phascolarctos cinereus* Fisch.

Abbreviations.

Pr. — protocone.
Pa. — paracone.
Me. — metacone.
Hy. — hypocone.
St. — external styles.

FIG. b, after Giebel (*Odontographie*, Taf. XVII, Fig. 10, *a*).

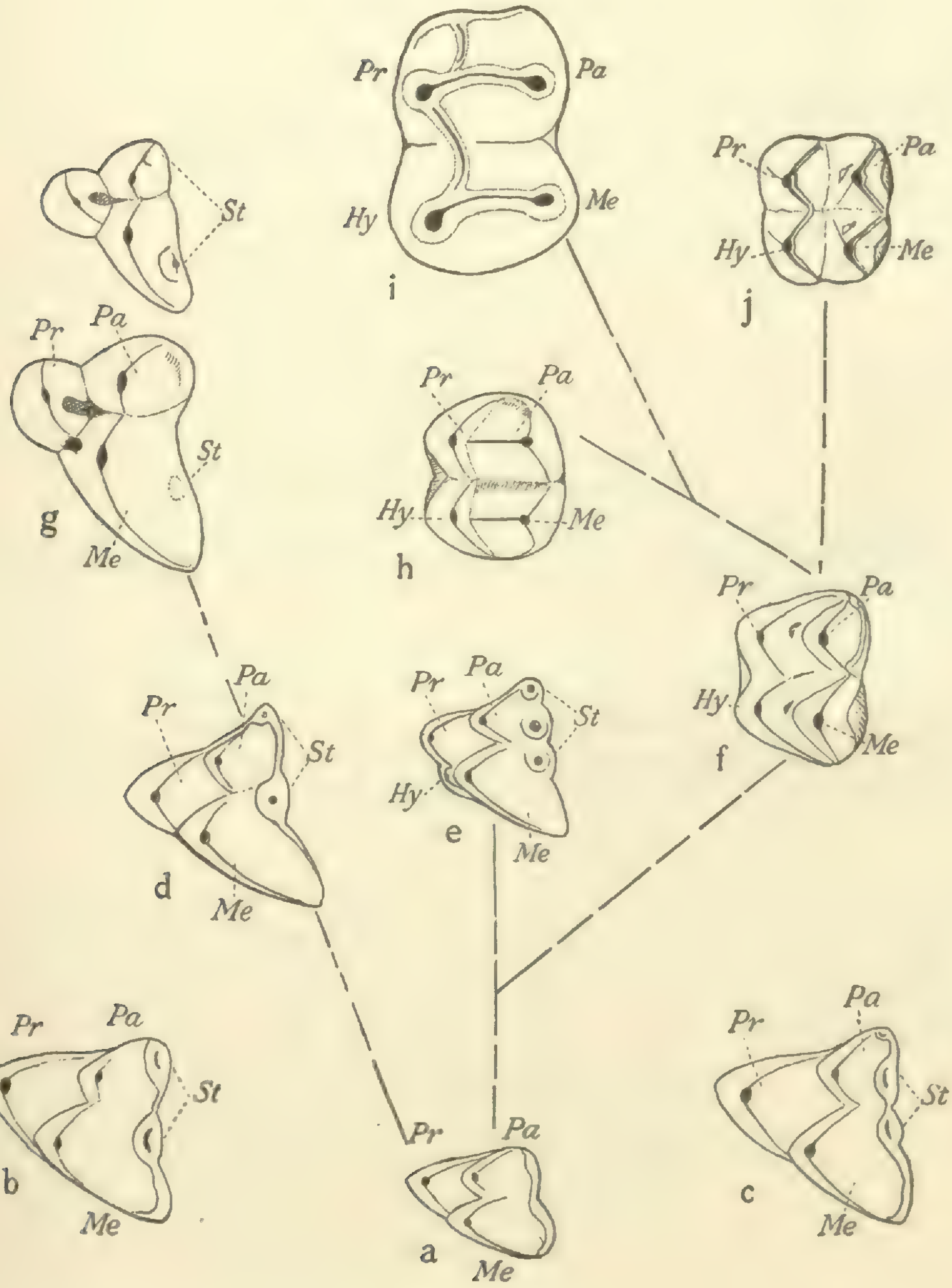

PLATE I.

EXPLANATION OF PLATE II.

Illustrating the patterns of the lower molar teeth in marsupials. (Same references as in Plate I.)

Abbreviations.

Pr^d. — protoconid.
Pa^d. — paraconid.
Me^d. — metaconid.
En^d. — entoconid.
Hy^d. — hypoconid.
Hl^d. — hypoconulid.
a.s. — antero-external shelf.

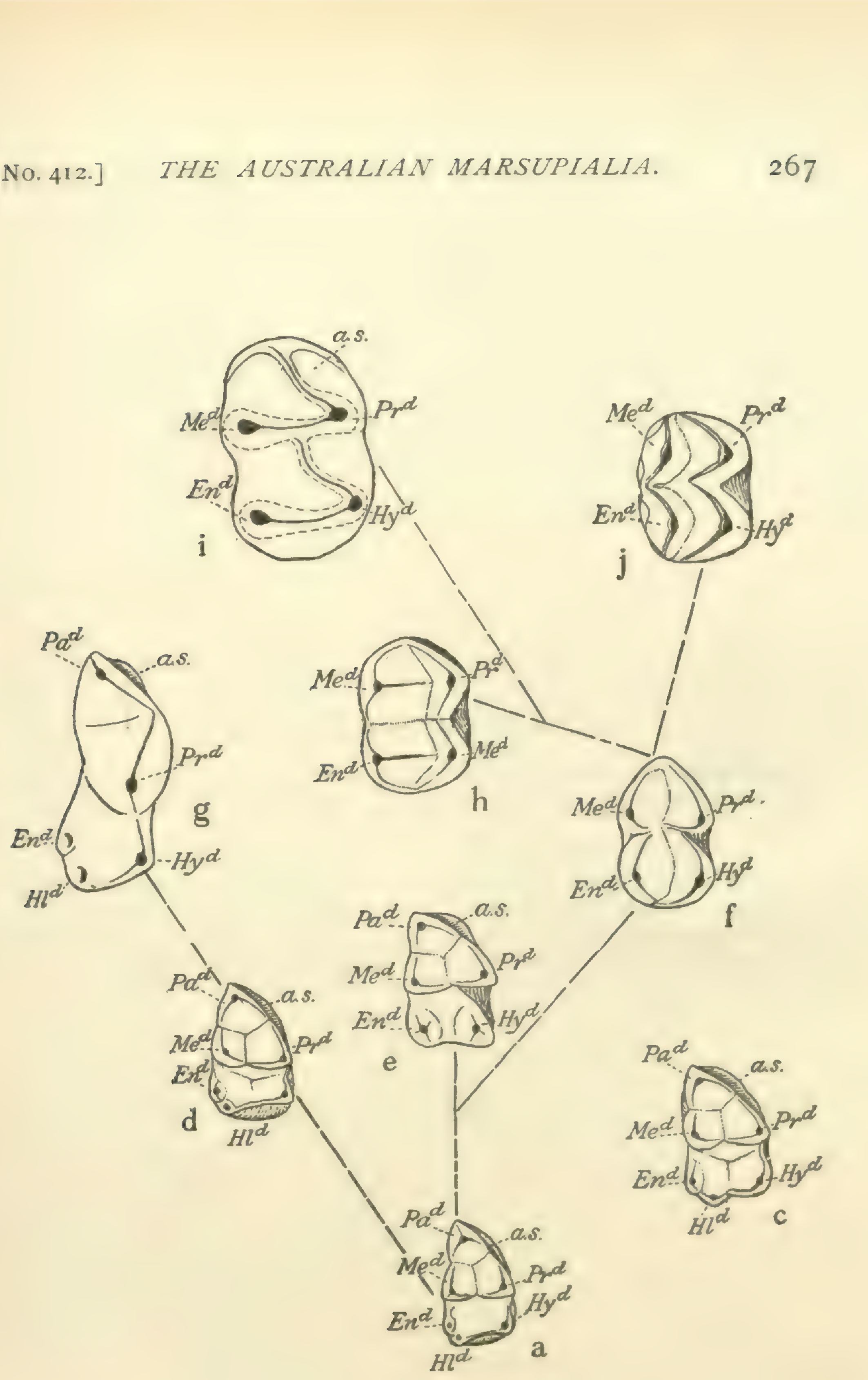

PLATE II.

EXPLANATION OF PLATE III.

Illustrating the modifications of the pes in Marsupials and their probable phylogenetic relations.

a. — *Didelphys nudicaudata* Geoff.
b. — *Phalanger celebensis* Gray.
c. — *Tarsipes rostratus* Gerv. & Verr.
d. — *Sminthopsis murina* Waterh.
e. — *Antechinomys laniger* Gould.
f. — *Phascolomys latifrons* Owen.
g. — *Perameles doreyana* Quoy & Gaim.
h. — *Peragale leucura* Thos.
i. — *Hypsiprymnodon moschatus* Rams.
j. — *Macropus sp.*

Figs. a–i after Dollo.

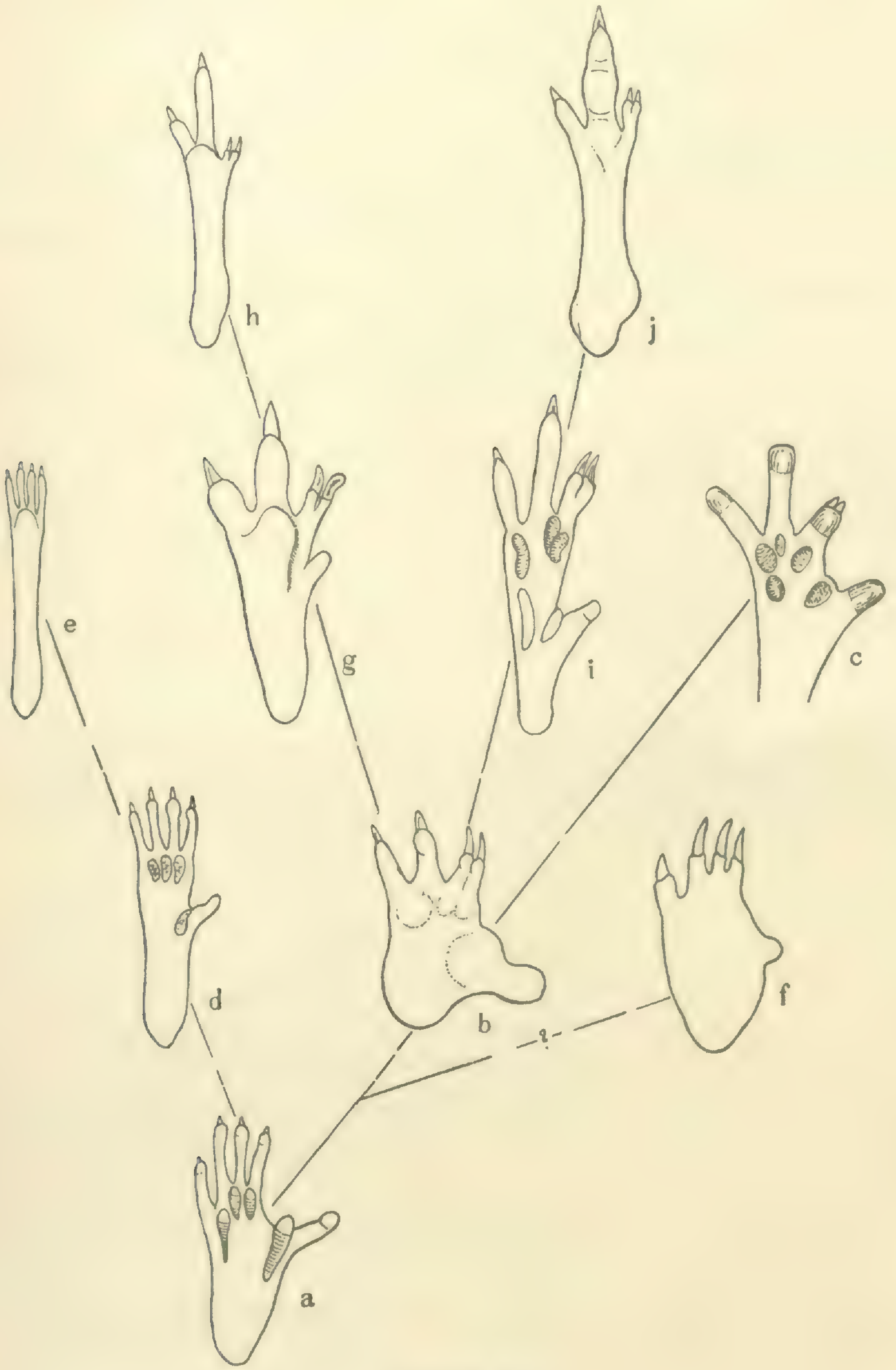

PLATE III.

CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE. E. L. MARK, DIRECTOR. No. 121.

A QUANTITATIVE STUDY OF VARIATION IN THE SMALLER NORTH-AMERICAN SHRIKES.

R. M. STRONG.

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I. INTRODUCTION.

THE work described in this paper was begun in the fall of 1898, and was carried on at Harvard University during the year 1898–99 under the direction of Dr. Charles B. Davenport. It was completed during the winter of 1899–1900.

It was my desire to employ statistical methods in the study of variation in a group of birds, and to apply the "Precise

Criterion of Species" of Davenport ('98) to a problem in bird classification. The smaller American shrikes of the genus Lanius appeared to me to offer favorable material for the application of quantitative methods to the solution of an interesting taxonomic problem.

The shrikes are a group of passerine birds more or less generally distributed in northern Europe and North America, and probably of circumboreal origin. The large northern shrike, *Lanius borealis* Vieill., of North America grades into the great gray shrike, *L. excubitor* Linn., of Europe; and it exhibits a strong tendency towards individual variation.

In the United States, Mexico, and southern Canada the breeding[1] shrikes are not essentially different from the northern shrike, *L. borealis*, in certain of its color phases, except for smaller size and the more or less complete disappearance of a conspicuous barring or mottling of the breast in adults. This barring of the breast is persistent in most adults of *L. borealis* and characteristic of the juvenile plumage of the southern shrikes, a fact of much phylogenetic interest.

According to the nomenclature of the American Ornithologists' Union there are at present recognized three races or subspecies of the southern or smaller shrikes, which are as follows: *Lanius ludovicianus ludovicianus* Linn., *L. ludovicianus excubitorides* Swains., and *L. ludovicianus gambelli* Ridgw. Subspecies *gambelli* includes the shrikes of California and vicinity. The shrikes of the rest of the country are classed as either ludovicianus or excubitorides, the former being typical in the south central states and the latter in the vicinity of Colorado.

The shrikes of New England and the north central states have been variously classed, by different systematists, as either ludovicianus or excubitorides. Palmer ('98) has proposed for the shrikes of this intermediate region a new subspecies, migrans, whose validity, I believe, can be well tested by the "Precise Criterion" method.

[1] In this paper the breeding range only is considered in discussing geographical distribution.

We have in the shrikes the following eight important variable characters:

1. Length of tail.
2. Length of wing.
3. Length of bill.
4. Depth of bill.
5. Curvature of culmen.
6. Color of dorsal surface of head and back.
7. Color of upper tail coverts.
8. Color of breast.

II. Material.

While the shrikes make good subjects for a study of variation, there has been an unfortunate difficulty in obtaining material in amounts as large as is desirable. Shrikes are not especially common birds in the regions most collected in, and they are considered rare in most parts of New England. They are certainly not abundantly represented in collections of birds, and many of the skins that were obtained were imperfect, or did not come from the breeding areas of the birds.

I have been able to procure measurements of two hundred and ninety-four available skins, obtained from the following sources:

Mr. William Brewster, Cambridge, Mass.	174 skins.
National Museum, Washington, D. C.	64 "
Museum of Comparative Zoölogy	18 "
Mr. J. H. Gaut, Washington, D. C.	15 "
Mr. C. F. Batchelder, Cambridge, Mass.	8 "
Dr. A. K. Fisher, Washington, D. C.	5 "
Mr. N. Hollister, Delavan, Wis.	4 "
Oberlin College Museum, Oberlin, Ohio	4 "
Carnegie Museum, Pittsburg, Pa.	1 "
Mr. William Palmer, Washington, D. C.	1 "

The numbers given do not include skins which, for various reasons, could not be used. I wish here to express my thanks to the gentlemen who have secured for me the loan of the above-mentioned material, and especially to Mr. William Brewster for many courtesies received.

GEOGRAPHICAL DISTRIBUTION.

	MALE.	FEMALE.		MALE.	FEMALE.
Arizona	16	13	Montana	4	3
British Columbia	1	0	Nevada	2	0
California	15	21	New Mexico	0	1
Colorado	1	2	New York	5	2
Connecticut	1	0	North Carolina	3	0
District of Columbia	6	2	North Dakota	1	0
Florida	45	23	Ohio	3	1
Georgia	8	6	Ontario	0	1
Illinois	10	3	Pennsylvania	1	1
Indiana	1	0	South Carolina	16	2
Indian Territory	0	1	Tennessee	1	1
Kentucky	1	0	Texas	7	5
Maine	0	1	Utah	0	1
Massachusetts	1	2	Virginia	4	10
Mexico	17	16	Wisconsin	0	1
Minnesota	1	0	Wyoming	3	1
			Total	174	120

III. METHODS.

A. General Precautions.

It is hardly necessary to say that work of this kind should be done with material in normal condition. I have made no measurements where mutilations existed, and only adult birds bearing good evidence of representing their breeding ranges have been used. It has been necessary to reject a number of skins because of lack of data as to sex. As male and female shrikes are essentially alike in color and differ little in size, it is not possible to verify the original determinations of sex; however, there has been no noticeable confusion in this respect.

No attention has been given to the subspecific distinctions appearing on the labels of skins, for I have considered it important to avoid all possibility of bias of opinion which attention to previous classification might give.

B. Measurements of Variable Characters.

1. *Linear Measurements. Length of Wing.* — The shortest distance between the wrist and the tip of the wing was measured with a pair of dividers, the wing being folded naturally at the side of the body. The left wing was taken in every case for the measurement.

Length of Tail. — This measurement was made from the papilla of the uropygial gland to the extreme end of the tail feathers. One arm of the dividers was placed with its point resting on the anterior face of the papilla. On account of mutilation and frequent difficulty in finding the papilla, the measurement has often to be omitted. Great precision cannot be obtained, as there is irregularity in the relative position of the papilla in the drying of the skin, and there is also usually some wearing away of the distal ends of the rectrices. When the latter were much frayed no measurement was attempted.

Length of Bill. — The only satisfactory method found for measuring the length of the bill was to take the shortest distance between the nostril and the distal apex of the upper mandible. The point of one arm of the dividers was placed against the most distal face of the nostril. I have had to make allowance in some cases for the wearing away of the distal apex of the upper mandible, though the amount of wear is too small to materially affect the measurement.

Depth of Bill. — The greatest dorso-ventral diameter of the bill near its base was determined. There is considerable liability to error here on account of lack of uniformity in the articulation of the mandibles in the dried skin, and I found it necessary to reject quite a number of skins on this account.

2. *Curvature of Bill.* — This is a character of the distal half of the culmen. Its quantitative expression is a matter of some difficulty, for we have here a curve which is not the arc of a circle nor a parabola, nor does it correspond to any geometrical figure. Then, too, the form and size of the bill are such as to render it impracticable to make precise measurements directly. To meet the latter difficulty it was decided to try to trace on paper the enlarged projection of the outline of the bill. After

some experimentation, the following apparatus was devised. Fig. 1 is a diagram of an enlarging camera with a box in front of the lens, at the left in the figure. A circular aperture for the passage of light was made in one side of the box, the oppo-

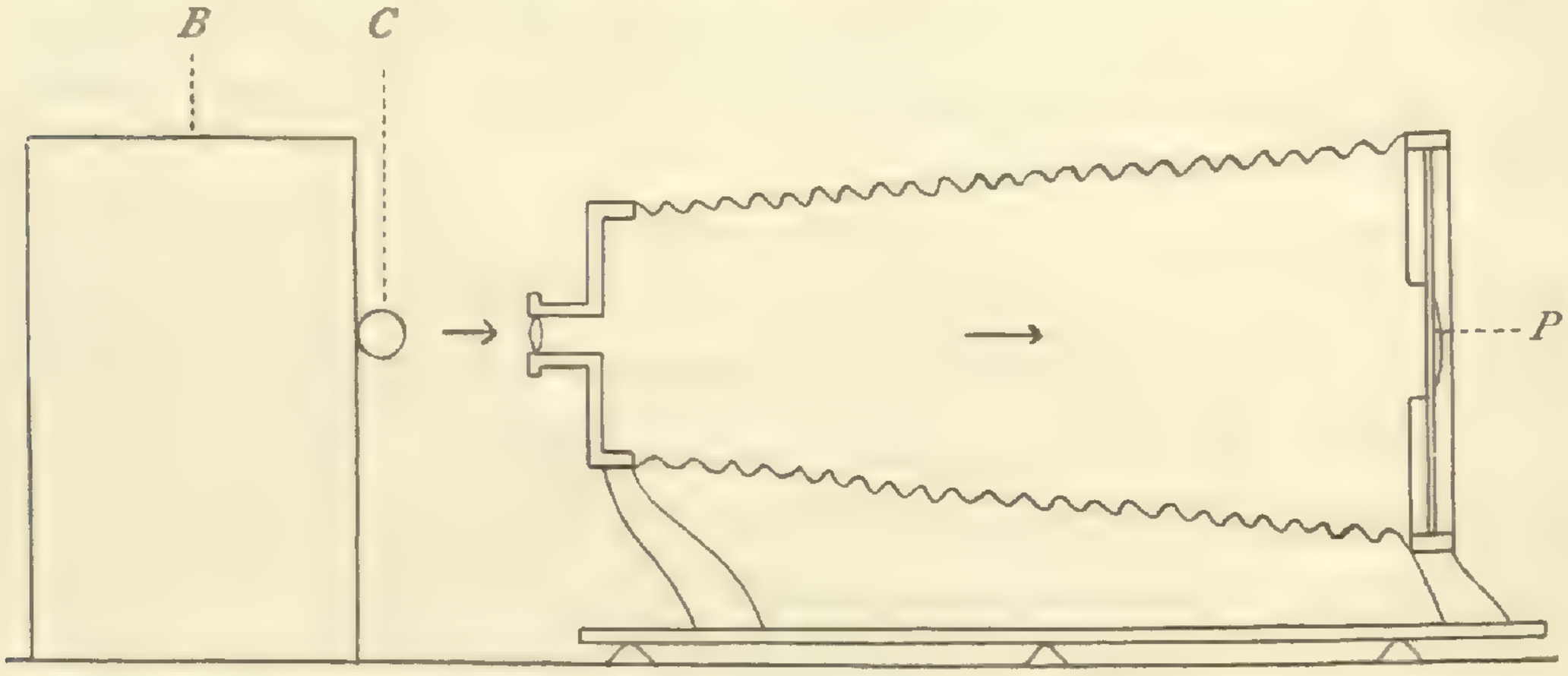

FIG. 1. — Longitudinal section of enlarging camera apparatus. *B*, box; *C*, paper cylinder; *P*, photographic paper in holder.

site side being removed. At one side of the aperture (*A*, Fig. 2) a simple cylinder (*C*, Figs. 1 and 2) of stiff paper just large enough to admit a shrike skin was fastened to the outside of the box in a nearly horizontal position by a single tack.

Orientation was then secured for any skin by the following simple adjustments: (1) rotation of the skin in the cylinder around its longitudinal axis; (2) rotation of the cylinder on the axis formed by the tack; (3) moving the skin in the cylinder towards or away from the aperture; (4) rotation of the box on a vertical axis.

The apparatus was arranged so that the bill of a shrike was about seven inches from the front of the lens and its median plane at right angles to the axis of the camera. Strong diffused daylight was then allowed to pass through the aperture of the box past the bill, and into the lens of the camera, as shown by the arrows in Fig. 1. In the plate-holder at the back of the camera was placed a piece of "velox" paper (a rapid printing photographic paper) about 2×3 inches

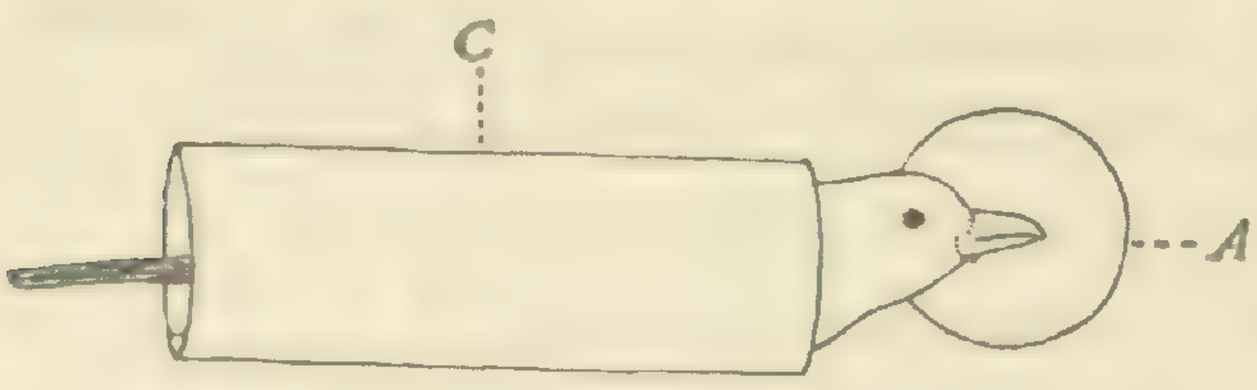

FIG. 2. — Paper cylinder (*C*) holding bird so that the bill projects before aperture (*A*).

in size. An exposure of seventy-five seconds was ordinarily sufficient to obtain a picture, which appeared on development as a white area on a black ground. A magnification of 3⅓ diameters was secured, care always being taken to have the distance of the bill from the lens constant. An outline of the culmen of practicable working size having been thus obtained, the next step was the analysis of the curve.

It was highly desirable to have one simple criterion of the curvature, if one sufficiently representative could be found. In Fig. 3, which represents the outline in a representative case, a great increase in the sharpness of the curvature is seen

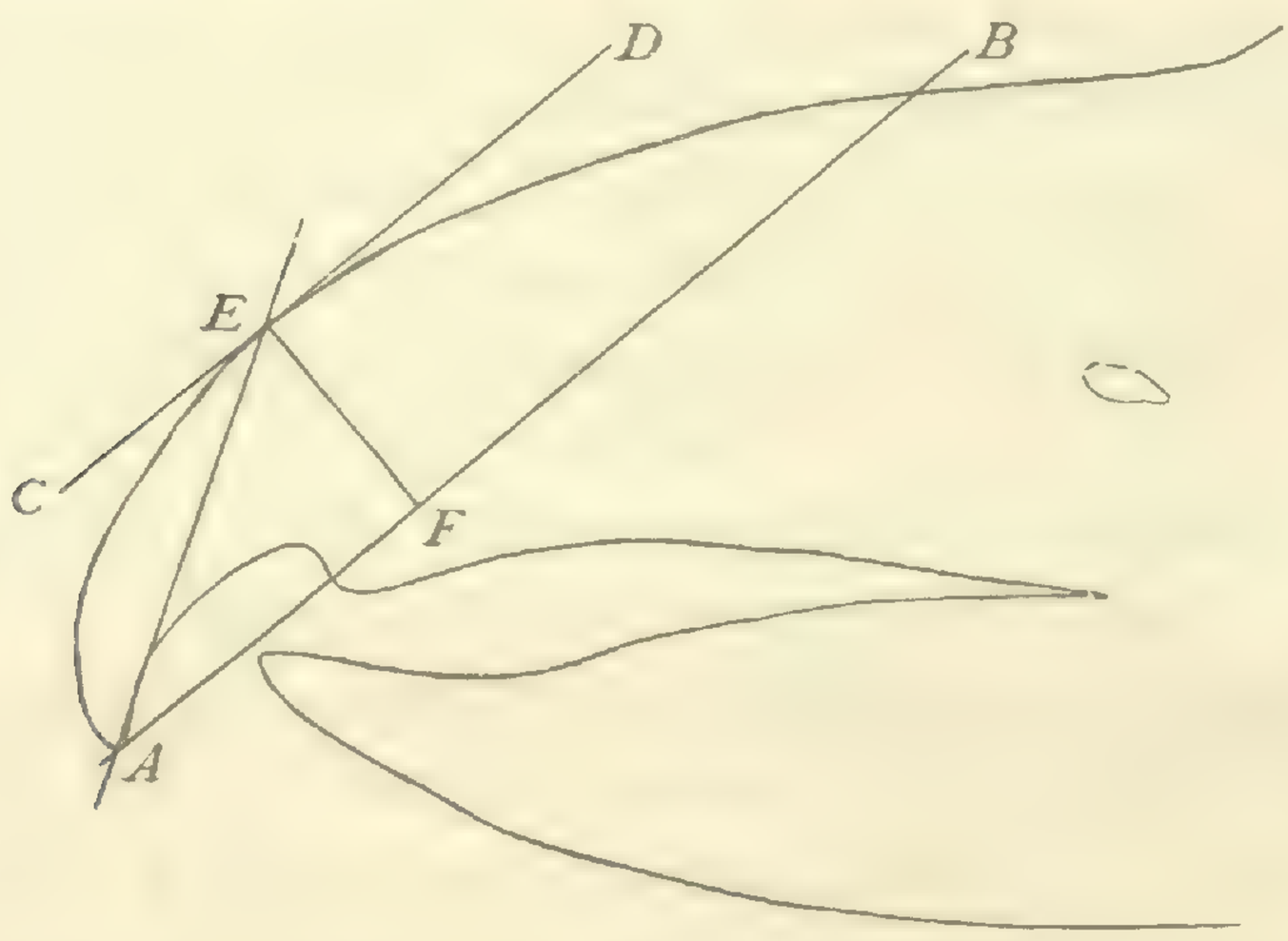

FIG. 3. — Diagram of bill showing method of measuring curvature of culmen. *A B* equals distance of *A* from nearest margin of nostril; *CD*, tangent to outline of culmen parallel to *A B*; *EF*, perpendicular at point of tangency, *E*; *EAF*, angle embraced between the two chords of the culmen, *A B* and *A E*.

towards the distal end of the culmen; the sharpness of curvature varies in different individuals. The point where the rapid increase begins was found on inspection to be sufficiently uniform in position to suggest the idea of comparing in different individuals the angle embraced between two chords of the curve of the culmen, each of them terminating at the distal end of the culmen. The proximal ends of the two chords were selected by the following method: one was established at a point on the culmen as far from its apex as the apex was from the nearest margin of the nostril. The distance of the nostril from the tip of the culmen, of course, could not be measured on the photographic silhouette print; it was therefore determined

by measuring the actual distance in the specimen and multiplying that value by the linear magnification of the print. The nostril distance was used because the nostril was found to be the only point sufficiently definite and constant for the proximal limit. This chord (*AB*, Fig. 3) served as a base line. A line (*CD*) parallel to the base line and tangent to the culmen was next drawn, and at the point of tangency (*E*) a perpendicular (*EF*) was erected between the lines. It was then a simple matter to measure the lines *AF* and *EF*, and with a table of natural tangents to determine the angle *EAF*. This is the angle that has been adopted as a criterion of curvature in the shrike bill. It is easily seen that there might be an infinite number of small variations in the outline of the culmen, especially in the part distal to the point *E*, which would not affect the angle *EAF*; but I believe that a correlation is to be expected between the curvatures in various portions of the culmen, so that it is probable that any considerable variation in outline elsewhere would affect the curvature in the region of *E* and thus find expression in the angle *EAF*. In order, however, to have something more than a subjective impression on this matter, I made a second series of measurements with half the length of the line *AB* used as a chord. The result of these measurements, and their deviations from those of the first set, are given on page 294.

3. *Color Measurements.*—For the quantitative determination of color, the "color mixer" was suggested. A simple form of color mixer — the Bradley Milton Color-Top — was employed. This instrument has a graduated disk, with superimposed paper disks of five different colors, which can be so adjusted as to make compound disks exposing two or more colors. On being rotated at high speed these colors are mixed into one, which is a combination of the colors used in the proportions of the number of degrees of each exposed. With the aid of this apparatus it is therefore possible to determine the proportions of these primary colors entering into any color effect which may be produced by various combinations of them. To determine the composition of any color in nature, it is necessary to reproduce empirically that color in the top and note the

combinations that have given the desired effect. In practice, however, the following conditions were found essential to accurate estimation of color: (1) Uniform strong diffused daylight, preferably coming from a skylight or north window and not subject to strong reflections from colored surfaces; (2) frequent comparison with previously made estimates; (3) careful comparison of the color obtained by the top with that of the plumage, whose color is being measured, both being viewed from different directions.

I found it impracticable to make color estimates for more than two hours continuously, because of color fatigue of the eye.

In spite of the above precautions, there are limitations to the use of the color-top. In the estimation of color, the personal equation plays an important part. Then, too, the surface of the color disks is very different in character from that of feathers. The peculiar luster or sheen so characteristic of a bird's plumage cannot be imitated by the color mixer. In estimating the color of the breast, more or less mottling, which exists in some cases, increased the difficulty. In such cases I have attempted to estimate the mean color. Some apparatus for blending a complex pattern into one color would be very desirable. I do not attempt to maintain that estimates of the same material by another person would exactly agree with mine; but I believe that I have a consistent classification of individuals according to color.

After several weeks of experimentation I found that, though there were traces of blue, red, and yellow, the colors black and white were by far the most important elements in the areas measured. Therefore I have taken as the color criterion the amount of black, or the melanism, of the color area described; and color estimates appear in the tables as percentages of melanism. I have found it more difficult to estimate colors containing more than 50% of white than those in which black predominated, and I have not attempted to make fine distinctions as to melanism in the lighter color areas. The large amount of black necessary to produce even the lightest grays in the color mixer was a matter of surprise to me. To

properly appreciate the estimates of color given in this paper, a color mixer should be used to reproduce the combinations given.

Ability in the discrimination of color I have found to be much developed by experience. The color determinations of my first three months' work were rejected, as increased power of discrimination made more accurate results possible.

C. Geographical Areas.

The material described in this paper has been collected from a territory of great size and varying conditions, and it is therefore desirable to compare individuals both as parts of a single group and in subdivisions corresponding to natural life areas, so that correlations between individual variability and geographical variation may be made. I have adopted the life areas employed by Allen ('93) for the territory covered by my material, which are four in number:

1. *Austroriparian Subprovince*, embracing North and South Carolina, Georgia, and Florida.

2. *Appalachian Subprovince*, embracing Maine, Massachusetts, Connecticut, District of Columbia, Virginia, Ontario, New York, Pennsylvania, Indiana, Kentucky, Ohio, Illinois, Wisconsin, Minnesota, and North Dakota.

3. *Campestrian Subprovince*, embracing British Columbia, Montana, Wyoming, Colorado, Indian Territory, New Mexico, Texas, Idaho, Utah, Arizona, and Nevada.

4. *Sonoran Subprovince*, embracing California, Lower California, and Mexico.

A comparison of variations for still smaller areas is desirable, but this, to be useful, would require more material than I have been able to obtain. The subspecies of shrikes have the distribution given by Palmer ('98), excepting gambelli (Palmer did not consider the western shrikes), which agrees very well with the above life areas. The inhabitants of each are:

SUBPROVINCE.	SUBSPECIES.
Austroriparian	= ludovicianus
Appalachian	= migrans
Campestrian	= excubitorides
[Sonoran	= gambelli]?

IV. Results.

A. Indices of Variability.

1. *Wing and Tail.* — In Figs. 4–8, frequency polygons based on measurements of various dimensions, the position of the mean class is indicated by a heavy vertical line. In Fig. 4 are given frequency polygons for the lengths of the wing (4 *A*) and tail (4 *B*) of all available male shrikes. They show a striking absence of variability for these characters in a series of individuals representing four subprovinces with greatly varying conditions.

In Tables I–III are given correlations between the length of wing and the length of tail. I have used the method of Duncker (Davenport, '99, p. 33) in determining coefficients of correlation. The "probable error" has also been determined by the following formula (Davenport, '99, p. 34), in which ρ is the coefficient of correlation.

$$\text{P. E. } \rho = \frac{0.6745\,(1-\rho^2)}{\sqrt{n}\,(1+\rho)}$$

On comparing Tables II and III, we find that Florida shrikes have a greater length of tail in relation to the length of wing than shrikes from the Appalachian subprovince.

The correlation in these characters for the series from the Appalachian subprovince is seen to be 0.157− greater than that of the Florida series. This difference is possibly due in part to the skewness of the curves of frequency for these series, which renders precise correlations difficult.

TABLE I. — 140 MALE SHRIKES FROM THE ENTIRE REGION.

Mean of wing = 99.06 + mm. Mean of tail = 101.571 + mm.
σ_1 = 2.74 + mm. σ_2 = 3.48 + mm.

		Wing, Subject.					Tail, Relative.						
	X_2		−7	−5	−3	−1	0	2	4	6	8		
	Rel. class		94	96	98	100	102	104	106	108	110	mm.	
	Sub. class (I)											(II)	
X_1													
94 mm.	−5	.			4	3	1						
96 mm.	−3	.	2	2	6	8	3		1				
98 mm.	−1	.	1	3	9	11	11	6	4				
100 mm.	0	.		1	5	9	6	7	6	2			
102 mm.	2	.			2	1	6	3	2				
104 mm.	4	.					1		5	3	3		
106 mm. (III)	6	.						2		1			(IV.)

$\rho = 0.5688 +$ P. E. $\rho = \pm 0.038 +$

TABLE II. — 41 MALE SHRIKES FROM FLORIDA.

Mean of wing = 97.463 + mm. Mean of tail = 102.292 + mm.
σ_1 = 2.29 + mm. σ_2 = 3.14 + mm.

	WING, SUBJECT.				TAIL, RELATIVE.				
X_2	−6	−4	−2	0	1	3	5	7	
Rel. class	96	98	100	102	104	106	108	110	mm.
Sub. class (I)									(II)
X_1									
94 mm. −3		4	3	1					
96 mm. −1	1		5	1					
98 mm. 0		1	1	7	4	3			
100 mm. 2				2	2	3	2		
102 mm. 4									
104 mm. (III) 6								1	(IV)

$\rho = 0.639 +$ P. E. $\rho = \pm 0.0487$

TABLE III. — 28 MALE SHRIKES FROM THE APPALACHIAN SUBPROVINCE.

Mean of wing = 99.357 + mm. Mean of tail = 99.43 + mm.
σ_1 = 2.31 + mm. σ_2 = 3.063 + mm.

	WING, SUBJECT.				TAIL, RELATIVE.				
X_2	−5	−3	−1		0	2	4	6	
Rel. class	94	96	98		100	102	104	106	mm.
Sub. class (I)									(II)
X_1									
96 mm. −3		2		1	1				
98 mm. −1		1	1	5	4				
100 mm. 0				2	4				
102 mm. 2				1		2	1	1	
104 mm. 4								1	
106 mm. (III) 6							1		(IV)

$\rho = 0.796 +$ P. E. $\rho = \pm 0.0348 +$

A general tendency towards great length of tail in southern birds has been noted by Allen ('71, pp. 230, 231). In Table VII, p. 291, the mode of lengths of tail for Austroriparian males is seen to be 102 mm.; whereas Appalachian males have a mode of 100 mm. The mean of Austroriparian shrikes is 101.91 + mm., while that of Appalachian shrikes is 99.43 + mm.,

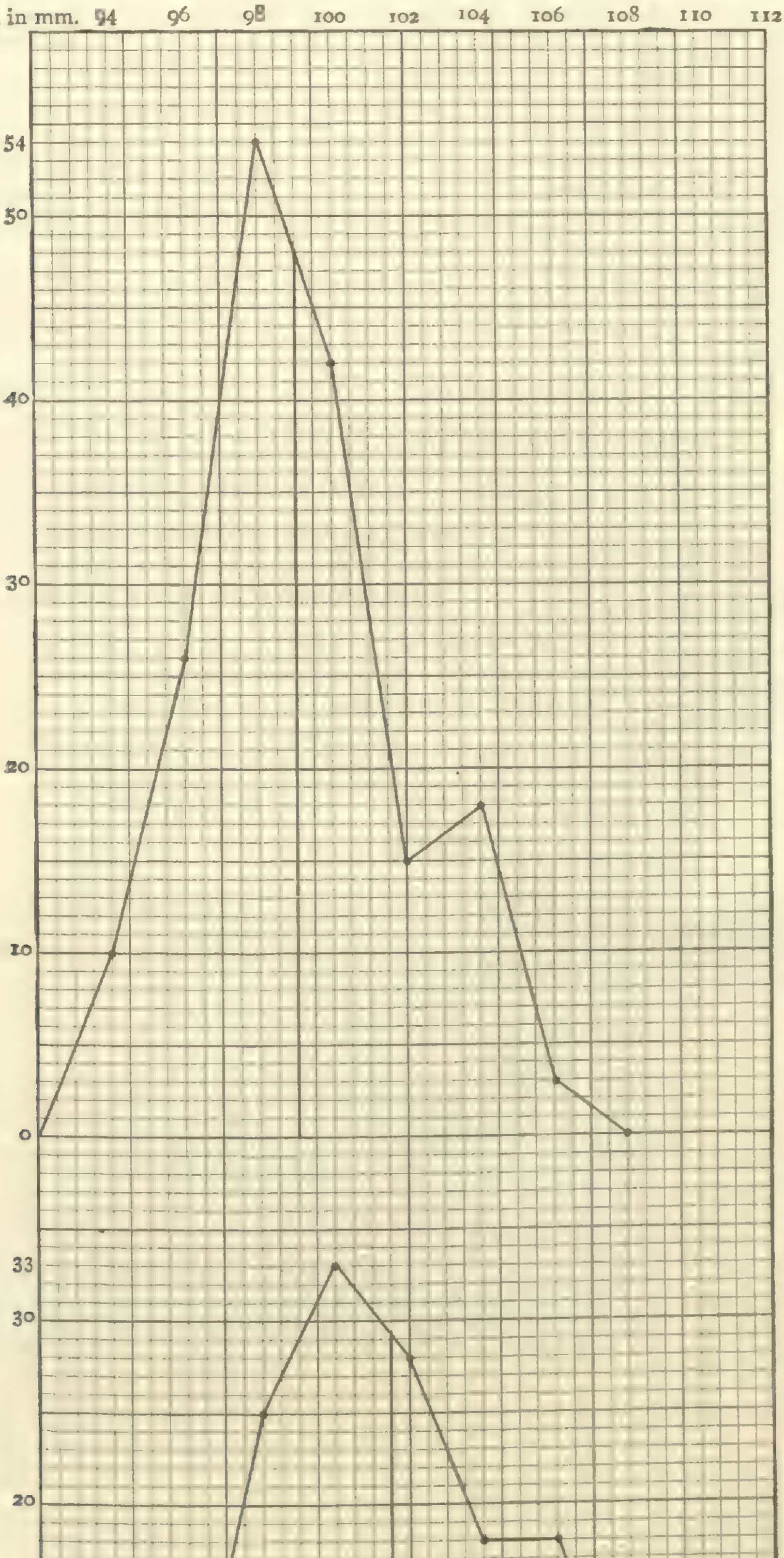

Fig. 4A.

Fig. 4B.

FIG. 4. — Frequency polygons. *A*, Classes of left wings for 168 males from entire region; *B*, tails of 141 males from entire region.

a difference of 2.48 mm. Austroriparian females show a still greater preponderance in length of tail, having a mode 6 mm. greater and a mean 3.05 mm. greater. Not much importance, however, can be attached to the great difference of the modes in this case, because of the small number of females measured.

Palmer ('98) says, in referring to shrikes of the Appalachian and Austroriparian subprovinces respectively: "In migrans

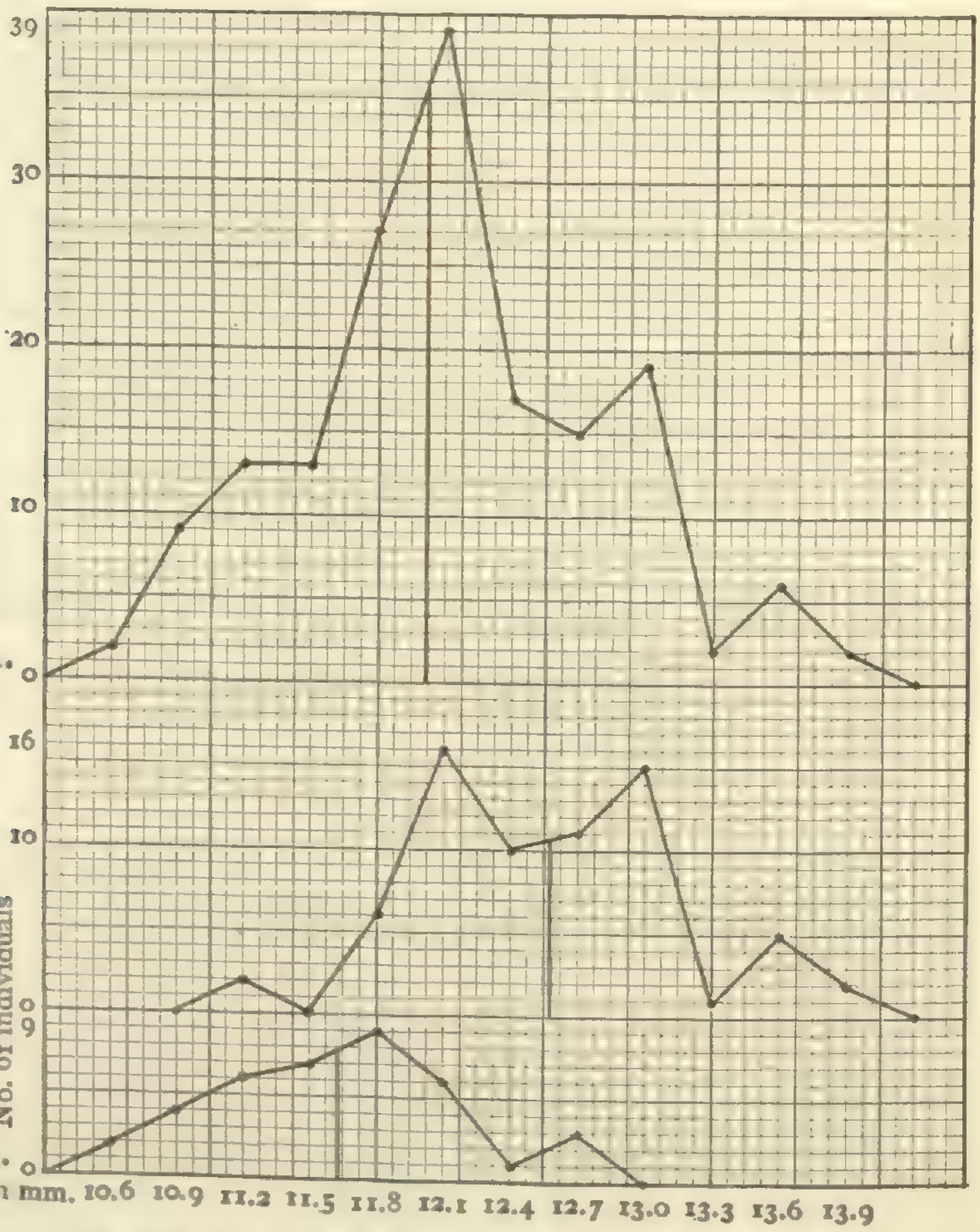

Fig. 5A.

Fig. 5B.

Fig. 5C.

FIG. 5. — Frequency polygons for length of bill. *A*, 164 males from entire region; *B*, 69 males from Austroriparian subprovince; *C*, 38 males from Appalachian subprovince.

[Appalachian] the wing is longer than the tail, due to its migratory habit; in ludovicianus [Austroriparian] the tail is longest, thus indicating its fixed habitat."

I find, on the contrary, that the wing is not absolutely longer than the tail in the Appalachian form, though from Tables VI and VII, pp. 290, 291, it is clear that the excess of the length of tail over that of the wing is less in migrans than in ludovicianus;

or, in other words, that *relatively to the tail*, the wing is longer in migrans than in ludovicianus, as his theory would require.

Palmer's explanation of length of wing in migrans as the result of habit is plausible. However, it has not been proved that shrikes which migrate northward actually fly any more than those remaining in Florida; moreover, it seems to me that there are other possible explanations. I am inclined to think that we have here a case of the condition already noted

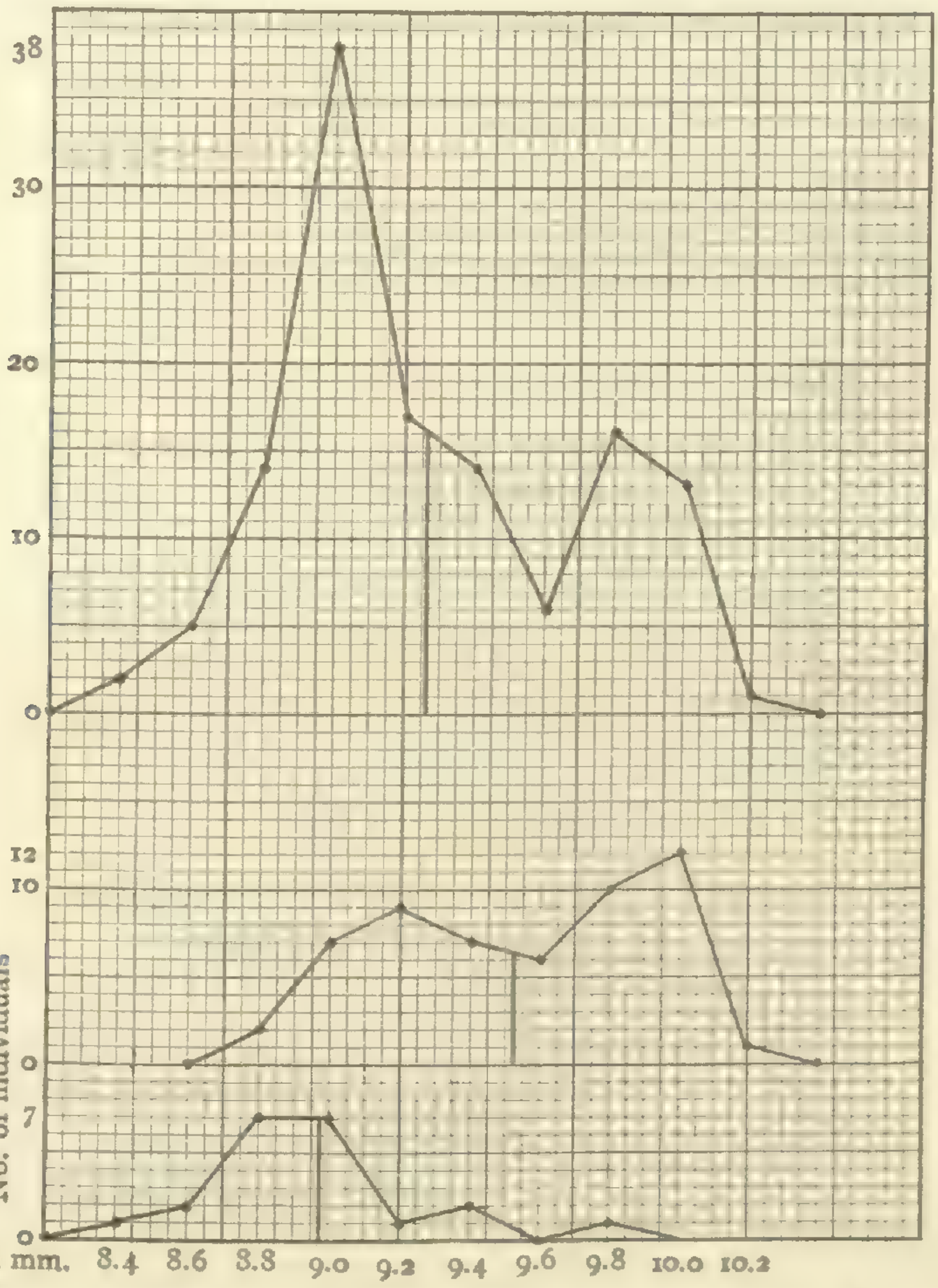

Fig. 6A.

Fig. 6B.

Fig. 6C.

FIG. 6. — Frequency polygons for depth of bill. *A*, 126 males from entire region; *B*, 54 males from Austroriparian subprovince; *C*, 21 males from Appalachian subprovince.

by Allen — a tendency towards greater length of tail in tropical birds. Unfortunately I cannot prove this, — any more than Palmer does his hypothesis, — for it has not been possible to determine the actual ratios of tail length and wing length with reference to the general size of the bird.

2. *Length and Depth of Bill.* — In Fig. 5 are given frequency polygons of variations in length of bill for the entire region and

for two subprovinces. Here is shown a considerable separation of the means (indicated by the vertical line) for the subprovince polygons, indicating a larger bill for Austroriparian shrikes (5*B*), which are also seen in Fig. 6*B* to have a greater depth of bill. The increase in size found in the bills of Florida shrikes is also shown by comparison of Tables IV and V, in which these characters are correlated for a series of Florida[1] shrikes and a series from the Appalachian subprovince. A striking absence of correlation and a great tendency towards individual variation in the proportions of the bill are to be seen. Increase in the relative size of the bill in many southern birds has been noted by Allen ('71). It would be an interesting field for statistical investigation.

TABLE IV. — 32 MALE SHRIKES FROM FLORIDA.

Classes of Depth of Bill.	Classes of Length of Bill in Millimeters.										Total.
	11.2	11.5	11.8	12.1	12.4	12.7	13.0	13.3	13.6	13.9	
8.8 mm. . .				1	1						2
9.0 mm. . .				1			1				2
9.2 mm. . .				2		1			1	1	5
9.4 mm. . .			1				1		1		3
9.6 mm. . .					2						2
9.8 mm. . .			1	1		1	1		2		6
10.0 mm. . .			1	5	1		4				11
10.2 mm. . .						1					1
Total . . .			3	10	4	3	7		4	1	32

3. *Color.* — Frequency polygons for variations in the melanism of the head are shown in Fig. 7. The upper polygon (Fig. 7*A*), which includes the entire series, is seen to be distinctly bimodal, and in the lower polygons we see that the mode of greater melanism is due to the presence of Austroriparian shrikes, and that the shrikes of the Campestrian subprovince have the least melanism for the dorsal surface of the head.

[1] Only Florida representatives of the Austroriparian shrikes were taken in this case, in order to eliminate intermediate forms, for it seemed desirable to me to compare the Appalachian shrikes with a group as nearly tropical as possible.

The Campestrian subprovince includes arid portions of the United States, where paleness of color in the fauna is supposed to be correlated with this condition.

TABLE V. — 22 MALE SHRIKES FROM THE APPALACHIAN SUBPROVINCE.

Classes of Depth of Bill.	Classes of Length of Bill in Millimeters.									Total.
	10.6	10.9	11.2	11.5	11.8	12.1	12.4	12.7	13.	
8.4 mm.			1							1
8.6 mm.	1								1	2
8.8 mm.			1	3		1				5
9.0 mm.	1	1	2	1	1	1		1		8
9.2 mm.			1			1				2
9.4 mm.				1		1	1			3
9.6 mm.										0
9.8 mm.			1							1
Total.	2	1	6	5	1	4	1	1	1	22

While such correlations are frequently suggested by the fauna of desert regions, the relations of humidity to color are still problems for further investigation.

Very great variations in the melanism of the upper tail coverts are shown in Fig. 8. The shrikes of the Campestrian subprovince have here also a mode of little melanism, 30%, while a mode of great melanism, 70%, is found for Austroriparian shrikes. The upper tail coverts of Campestrian shrikes, especially those from Colorado and Arizona, are very light gray. This peculiarity has caused the race to be designated as the white-rumped shrikes.

B. Tables of Constants of Frequency Polygons.

In Tables VI–XIII will be found indices of variation for all the material studied. All computations have been made from measurements grouped into classes. This grouping has been adopted both in drawing the polygons and in determining the indices of variability, in order to reduce the "probable error."

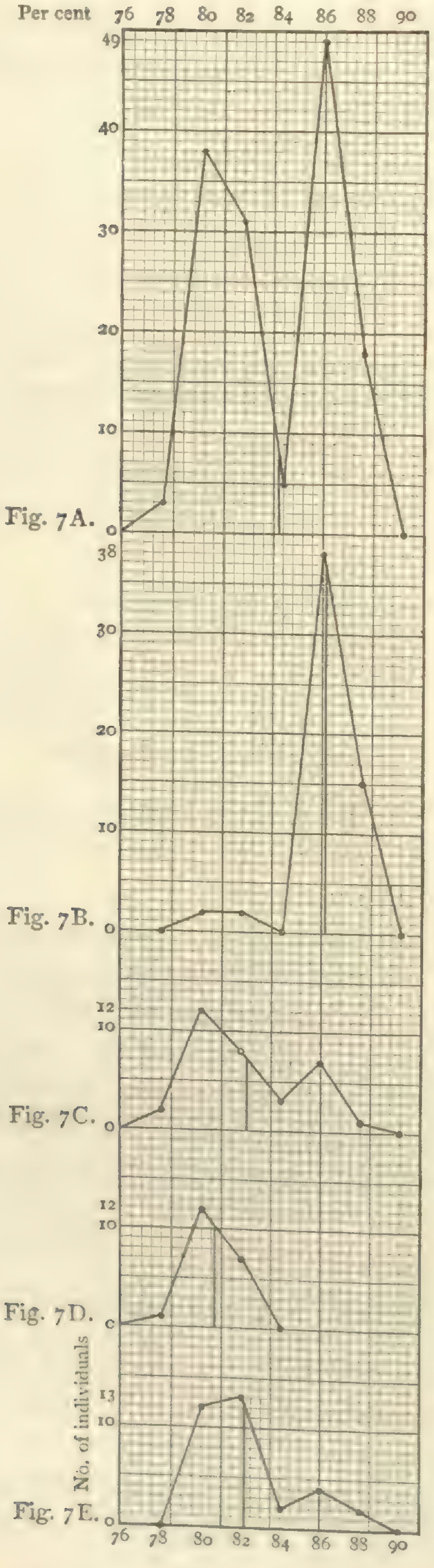

FIG. 7. — Frequency polygons for melanism of top of head. *A*, 144 males from entire region; *B*, 57 males from Austroriparian subprovince; *C*, 33 males from Appalachian subprovince; *D*, 21 males from Campestrian subprovince; *E*, 33 males from Sonoran subprovince.

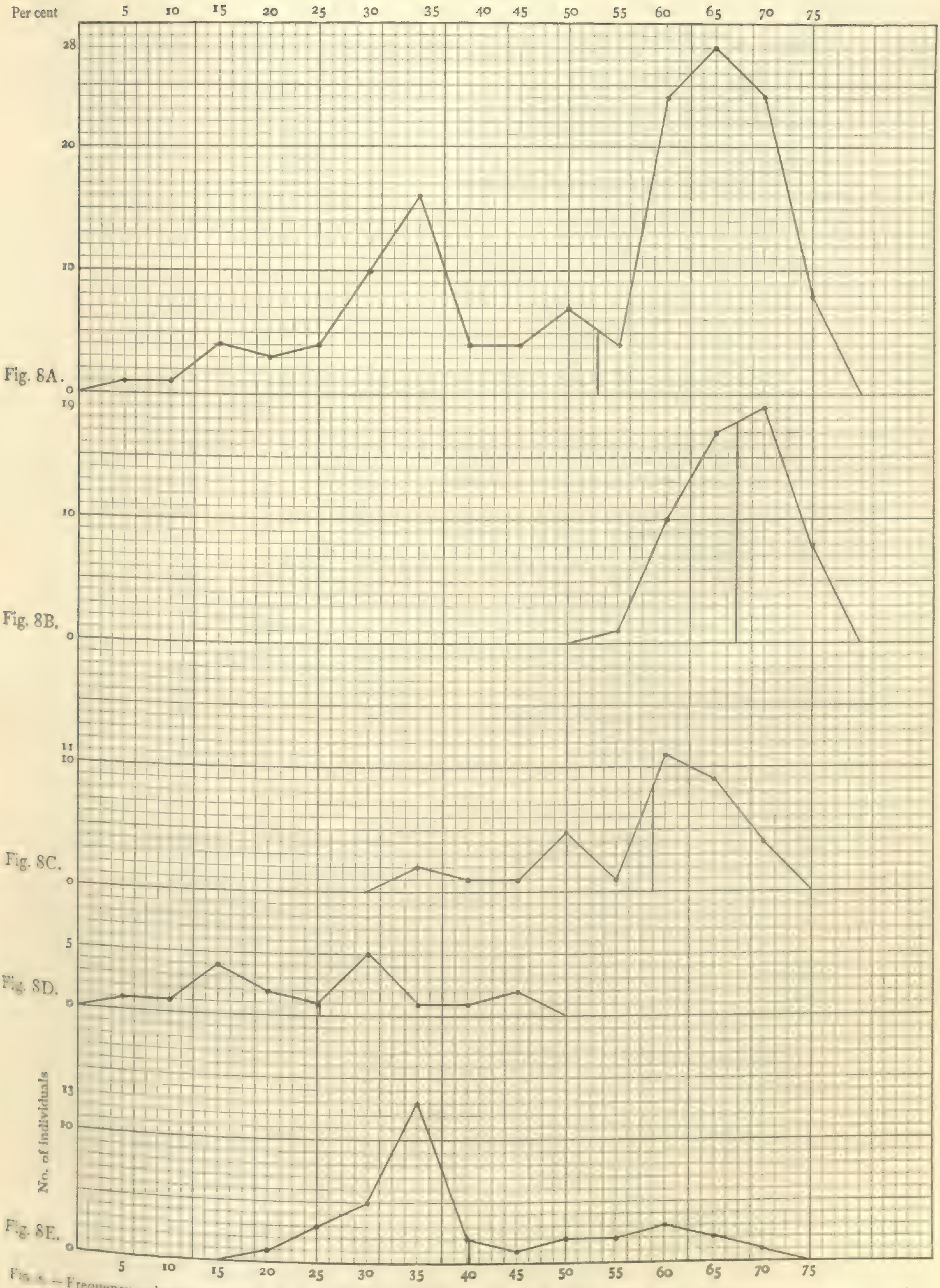

Fig. 8. — Frequency polygons for melanism of upper tail coverts. *A*, 142 males from entire region; *B*, 55 males from Austroriparian subprovince; *C*, 34 males from Appalachian subprovince; *D*, 18 males from Campestrian subprovince; *E*, 35 males from Sonoran subprovince.

The following constants of the frequency polygons have been determined (Davenport, '99) :

1. Mode : Class of greatest frequency.
2. Mean : $M. = \frac{\Sigma (V. f)}{n}$.
3. Standard Deviation, $\sigma = \sqrt{\frac{\Sigma (x.^2 f)}{n}}$.
4. Coefficient of variability : $CV. = \frac{\sigma}{M} \times 100$.
5. Probable error of Mean : $P. E. M.$ [sub.] $= \pm 0.6745 \frac{\sigma}{\sqrt{n}}$.
6. Probable error of Standard Deviation : $P. E. \sigma$ [sub.] $= \pm 0.6745 \frac{\sigma}{\sqrt{2n}}$.

TABLE VI. — LENGTH OF LEFT WING.

AREA.	MATERIAL.	MODE.	MEAN.	STANDARD DEV.
Entire region .	168 males.		99.09 + mm.	2.79 + mm.
	112 females.		97.98 + mm.	2.64 + mm.
Austroriparian .	70 males.	98 mm.	97.6 + mm.	2.04 + mm.
	31 females.	96 mm.	96.64 + mm.	2.35 + mm.
Appalachian . .	35 males.	98–100 mm.	99.2 mm.	2.45 + mm.
	25 females.	98 mm.	97.68 mm.	2.17 + mm.
Campestrian . .	27 males.	104 mm.	101.26 mm.	2.45 + mm.
	24 females.	102 mm.	99.75 mm.	2.79 + mm.
Sonoran . . .	36 males.	98 mm.	100.28 mm.	2.90 + mm.
	32 females.	98 mm.	98.19 + mm.	2.36 + mm.

CV. of 168 males = 2.81 +. *CV.* of 112 females = 2.69 +.

P. E. M. [sub.] 168 males = ± 0.145.

P. E. σ [sub.] 168 males = ± 0.1026 +.

Table VII. — Length of Tail.

Area.	Material.	Mode.	Mean.	Standard Dev.
Entire region .	141 males.		101.55 + mm.	3.49 + mm.
	95 females.		99.55 + mm.	3.63 + mm.
Austroriparian .	65 males.	102 mm.	101.91 + mm.	3.12 + mm.
	30 females.	104 mm.	100.47 + mm.	3.25 + mm.
Appalachian . .	28 males.	100 mm.	99.43 + mm.	3.06 + mm.
	19 females.	98 mm.	97.42 + mm.	3.85 + mm.
Campestrian . .	20 males.	104 mm.	102.3 mm.	3.48 + mm.
	18 females.	102 mm.	99.89 + mm.	3.42 + mm.
Sonoran . . .	28 males.	100 mm.	102.21 + mm.	3.90 + mm.
	28 females.	102 mm.	99.43 + mm.	3.88 + mm.

CV. of 141 males = 3.43 +. *CV.* of 95 females = 3.65 +.
P. E. M [sub.] 141 males = ± 0.198 +.
P. E. σ [sub.] 141 males = ± 0.14008 +.

Table VIII. — Length of Bill.

Area.	Material.	Mode.	Mean.	Standard Dev.
Entire region .	164 males.		12.01 + mm.	0.71 + mm.
	112 females.		11.71 + mm.	0.63 + mm.
Austroriparian .	69 males.	12.1 mm.	12.58 + mm.	0.59 + mm.
	30 females.	12.1 mm.	12.17 + mm.	0.51 + mm.
Appalachian . .	38 males.	11.8 mm.	11.63 + mm.	0.56 + mm.
	29 females.	11.9 mm.	11.26 + mm.	0.54 + mm.
Campestrian . .	25 males.	12.1 mm.	11.84 + mm.	0.63 + mm.
	20 females.	12.1 mm.	11.57 + mm.	0.51 + mm.
Sonoran . . .	32 males.	12.1 mm.	11.96 + mm.	0.54 + mm.
	35 females.	12.1 mm.	11.76 + mm.	0.53 + mm.

CV. of 164 males = 5.89 +. *CV.* of 112 females = 5.35 +.
P. E. M. [sub.] 164 males = ± 0.0374 +.
P. E. σ [sub.] 164 males = ± 0.0264 +.

TABLE IX. — DEPTH OF BILL.

AREA.	MATERIAL.	MODE.	MEAN.	STANDARD DEV.
Entire region .	126 males.		9.27 + mm.	0.42 + mm.
	85 females.		8.95 + mm.	0.41 + mm.
Austroriparian .	54 males.	10.0 mm.	9.54 + mm.	0.38 + mm.
	22 females.	9.2 mm.	9.32 + mm.	0.37 + mm.
Appalachian . .	21 males.	8.8–9.0 mm.	8.95 + mm.	0.30 + mm.
	19 females.	8.8 mm.	8.90 + mm.	0.36 + mm.
Campestrian . .	19 males.	9.0 mm.	9.08 + mm.	0.28 + mm.
	14 females.	8.8 mm.	8.8 + mm.	0.30 + mm.
Sonoran . . .	32 males.	9.0 mm.	9.12 + mm.	0.44 + mm.
	30 females.	8.8–9.0 mm.	8.78 + mm.	0.36 + mm.

CV. of 126 males = 4.57 +. *CV.* of 85 females = 4.61 +.
P. E. M. [sub.] 126 males = ± 0.0252 +.
P. E. σ [sub.] 126 males = ± 0.0178 +.

TABLE X. — MELANISM OF TOP OF HEAD.

AREA.	MATERIAL.	MODE.	MEAN.	STANDARD DEV.
Entire region .	144 males.		83.57 + %.	3.00 + %.
	99 females.		83.66 + %.	3.19 + %.
Austroriparian .	57 males.	86%.	86.17 + %.	1.69 + %.
	24 females.	88%.	87.25 + %.	1.81 + %.
Appalachian . .	33 males.	80%.	82.24 + %.	2.68 + %.
	25 females.	80%.	82.32 + %.	3.03 + %.
Campestrian . .	21 males.	80%.	80.67 + %.	1.13 + %.
	17 females.	80%.	80.94 + %.	1.78 + %.
Sonoran . . .	33 males.	82%.	82.24 + %.	2.4 + %.
	33 females.	82%.	83.45 + %.	2.38 + %.

CV. of 144 males = 3.58 +. *CV.* of 99 females = 3.81 +.
P. E. M. [sub.] 144 males = ± 0.1686.
P. E. σ [sub.] 144 males = ± 0.119 +.

Table XI. — Melanism of Upper Tail Coverts.

Area.	Material.	Mode.	Mean.	Standard Dev.
Entire region .	142 males.		53.13 + %.	15.42 + %.
	104 females.		47.98 + %.	18.99 + %.
Austroriparian .	55 males.	70%.	67.22 + %.	5.02 + %.
	25 females.	65%.	66.2 %.	8.16 + %.
Appalachian . .	34 males.	60%.	58.38 + %.	9.3 + %.
	20 females.	60%.	53.2 %.	6.4 + %.
Campestrian . .	18 males.	30%.	25.28 + %.	11.4 + %.
	17 females.		28.25 + %.	14.8 + %.
Sonoran . . .	35 males.	35%.	40.43 + %.	13.01 + %.
	43 females.	30%.	38.26 + %.	13.37 + %.

CV. of 142 males = 29.02 +. *CV.* of 104 females = 39.58 +.
P. E. M. [sub.] 142 males = ± 0.873 +.
P. E. σ [sub.] 142 males = ± 0.617 +.

Table XII. — Melanism of Breast.

Area.	Material.	Mode.	Mean.	Standard Dev.
Entire region .	124 males.		31.21 + %.	11.07 + %.
	98 females.		36.58 + %.	10.51 + %.
Austroriparian .	42 males.	25%.	23.81 + %.	6.66 + %.
	27 females.	35%.	32.41 + %.	10.36 + %.
Appalachian . .	35 males.	35%.	43.28 + %.	9.4 %.
	23 females.	40%.	47.61 + %.	8.71 + %.
Campestrian . .	17 males.	25%.	27.65 + %.	7.27 + %.
	18 females.	35%.	31.39 + %.	6.63 + %.
Sonoran . . .	30 males.	25%.	29.5 %.	6.65 + %.
	30 females.	35%.	35.0 %.	7.30 + %.

CV. of 124 males = 35.48 +. *CV.* of 98 females = 28.72 +.
P. E. M. [sub.] 124 males = ± 0.6709 +.
P. E. σ [sub.] 124 males = ± 0.474 +.

Because of limited time I was unable to obtain measurements of culmen curvature for more than forty-seven individuals (partly males and partly females), a number so small that a rather large probable error is found for coefficients of variability.

The results obtained are given in the following table.

TABLE XIII. — CURVATURE OF CULMEN.

	23°	24°	25°	26°	27°	28°	29°	30°	31°	32°	33°	34°	35°	36°	MEAN.
Austroriparian	1					1	1	1	2						28.66° +
Appalachian .				3	2	2	4	5	2	3	1				29.32° +
Campestrian .					2	4	1	1	1	0	2	2	2	1	31.00°
Sonoran . .								1	1				1		32.00°
Total	1			3	4	7	6	8	6	3	3	2	3	1	29.936°

Austroriparian	$\sigma = 2.74° +.$	$CV. = 9.58 +.$	$P.E.\ \sigma = \pm 0.534 +.$
Appalachian	$\sigma = 2.03° +.$	$CV. = 6.92 +.$	$P.E.\ \sigma = \pm 0.206 +.$
Campestrian	$\sigma = 3.12° +.$	$CV. = 10.06 +.$	$P.E.\ \sigma = \pm 0.372 +.$
Sonoran	$\sigma = 2.16° +.$	$CV. = 6.75.$	$P.E.\ \sigma = \pm 0.594 +.$
Total	$\sigma = 2.74° +.$	$CV. = 9.15 -.$	$P.E.\ \sigma = \pm 0.191 +.$

The shrikes of the Austroriparian subprovince, mostly Florida birds, are seen to have a mean curvature 3.34° — less than that of the Sonoran birds measured. With so few individuals precise statements as to curvature are not very reliable, but I believe that the figures given are approximately correct for the four subprovinces represented. The series of measurements of the curvature of the culmen when half the base line *A B* (Fig. 3) was used as the chord gave the following constants and coefficients of variability for the forty-seven individuals measured in the first series: Mean, 26.34° +; Mode, 27°; $\sigma = 2.33° +$; $CV. = 8.85$; $P.E.\ \sigma = \pm 0.162 +.$

The angles obtained from the second series of measurements were never greater than those from the first series. The greatest deviation from the first set of measurements was 7°, which occurred in four cases. All the deviations are indicated in the following table:

0°	1°	2°	3°	4°	5°	6°	7°
4	2	6	10	10	7	4	4 individuals.

It was impossible to get as accurate results in the second series, because of greater difficulty in determining the actual point of tangency, but the results obtained show that there is a fairly close correlation in the curvature for various parts of the bill; that is, where the culmen is much curved in one place, it is likely to have correspondingly strong curvature at other points.

The only selection exercised in the whole work was employed in the estimation of curvature, individuals which appeared on inspection to be typical for their respective subprovinces having been chosen, since it was impossible, for want of time, to photograph the entire series.

C. Discussion of Results and Conclusions.

Although computations have been carried out to the third or fourth decimal place, figures beyond the second decimal place are not given, as they would imply a degree of precision which is not attainable in an investigation of this kind. For example, the mean length of wing for 168 male shrikes is seen to be (see Table VI) 99.09 + mm. It often happened in making correlations that, because of general wear or some special mutilation to a single character, some individuals could not be included in a correlation table. This has happened especially often in the case of the tail, so that in the correlation table for wings and tails only 140 of the 168 male shrikes could be included. The mean for the left wings of the series of 140 shrikes was found to be 99.06 mm. (see Table I), a result which differs from the mean of the whole lot (168) by 3 in the second decimal place.

The modes and means given for the melanism of the breasts of Appalachian-subprovince shrikes show a percentage which, though higher than in other subprovinces, is not as high as would have been the case had not a large proportion of individuals come from localities intermediate between the Campestrian and Appalachian subprovinces. Shrikes from New England were found to have 50–60% of melanism for the breast. An analysis of material shows that only five skins

were obtained from New England, whereas Illinois alone is represented by thirteen. This lack of equalization in the sources of material prevents certain desirable interpretations of tendencies towards minor variations.

To my mind one of the most important results reached is the determination of the relative variability of different characters in a group of birds representing geographical areas of considerable size. The coefficients of variability (Tables VI–VII) indicate for the wing and tail a variability of less than 4 in length. The bill is somewhat more variable, as is shown by a coefficient of 5.89 + for the length of bill in a series of 164 males. Color, as would be expected, is much more subject to variation. The upper tail coverts and breast are the most variable; but the coverts furnish only a very small part of a bird's coloration, and the color of the breast was the character which it was the most difficult to measure satisfactorily, especially as advanced age and the condition of the plumage are factors of possible importance which I have found it difficult to consider. Fortunately for this particular study, shrikes do not change much after the first winter plumage is obtained.

I believe that migrans is as worthy of recognition as gambelli. Whether it is profitable to encumber nomenclature with the names of these races, based on slight variations, is a question which is worthy of further consideration.

The power of discriminating fine shades of color varies in different persons, and it can be highly developed by education. At the present time there is much activity among certain systematists in the production of new subspecies for geographical varieties, which long experience and special adeptness enable them to distinguish. A variation, no matter how slight, that can be correlated with geographical range is considered to warrant an addition to nomenclature; but the discovery and description of geographical races can be carried on almost *ad infinitum*.

Birds, because of their powers of flight, might be expected to be less subject to the factor of isolation than non-migratory animals, but the tendency to return in spring to the same breeding place must, in some species at least, be conducive to

the formation of numerous local variations, or family characteristics, whose recognition is a matter of power of discrimination on the part of the systematist.

It seems highly desirable that the question of limiting the establishment of new subspecies or varieties by some generally accepted criteria be considered.

I do not argue for the universal use of the method of the "Precise Criterion," but I believe that it is both desirable and practicable to employ it in certain problems of taxonomy, such, for instance, as the one just discussed. The ordinary work of classification, perhaps, does not at present require the precision in treatment furnished by purely quantitative methods, but problems of race distinction, I believe, need the precision of the "Precise Criterion." The contention that quantitative methods are less useful than those ordinarily employed because of the large amount of material required, is mischievous, for it argues that generalizations professing precision are possible by methods which are not precise. The problems of finer classification can be properly settled only by the use of a large amount of material, whatever the methods used.

V. Summary.

Quantitative methods have here been applied to the study of variation in the smaller shrikes of North America, and the following variable characters have been measured:

1. Length of wing.
2. Length of tail.
3. Length of bill.
4. Depth of bill.
5. Curvature of culmen.
6. Color of dorsal surface of head.
7. Color of upper tail coverts.
8. Color of breast.

The three color areas have been found to vary principally in the amount of melanism present. A series of 294 shrike skins from various parts of the United States, Mexico, and southern Canada have been studied and measurements of these skins have been classified.

Coefficients of variability have been determined as follows for the whole series.

	Males	Females
Length of wing	2.81 +	2.69 +
Length of tail	3.43 +	3.65 +
Length of bill	5.89 +	5.35 +
Depth of bill	4.57 +	4.61 +
Melanism of top of head	3.58 +	3.81 +
Melanism of upper tail coverts	29.02 +	39.58 +
Melanism of breast	35.48 +	28.72 +
Curvature of culmen	47 males and females 9.15 −	

Florida shrikes were found to have relatively large bills and long tails.

A large percentage of melanism has been found for the top of head and the back of shrikes from the south central states, while shrikes from the vicinity of Colorado and Arizona have a relatively small percentage of melanism for all three color surfaces measured.

I wish to make acknowledgments to Dr. Davenport for supervision of the work and helpful criticisms, and to Dr. Mark for suggestions and revision of the manuscript.

Cambridge, Mass.

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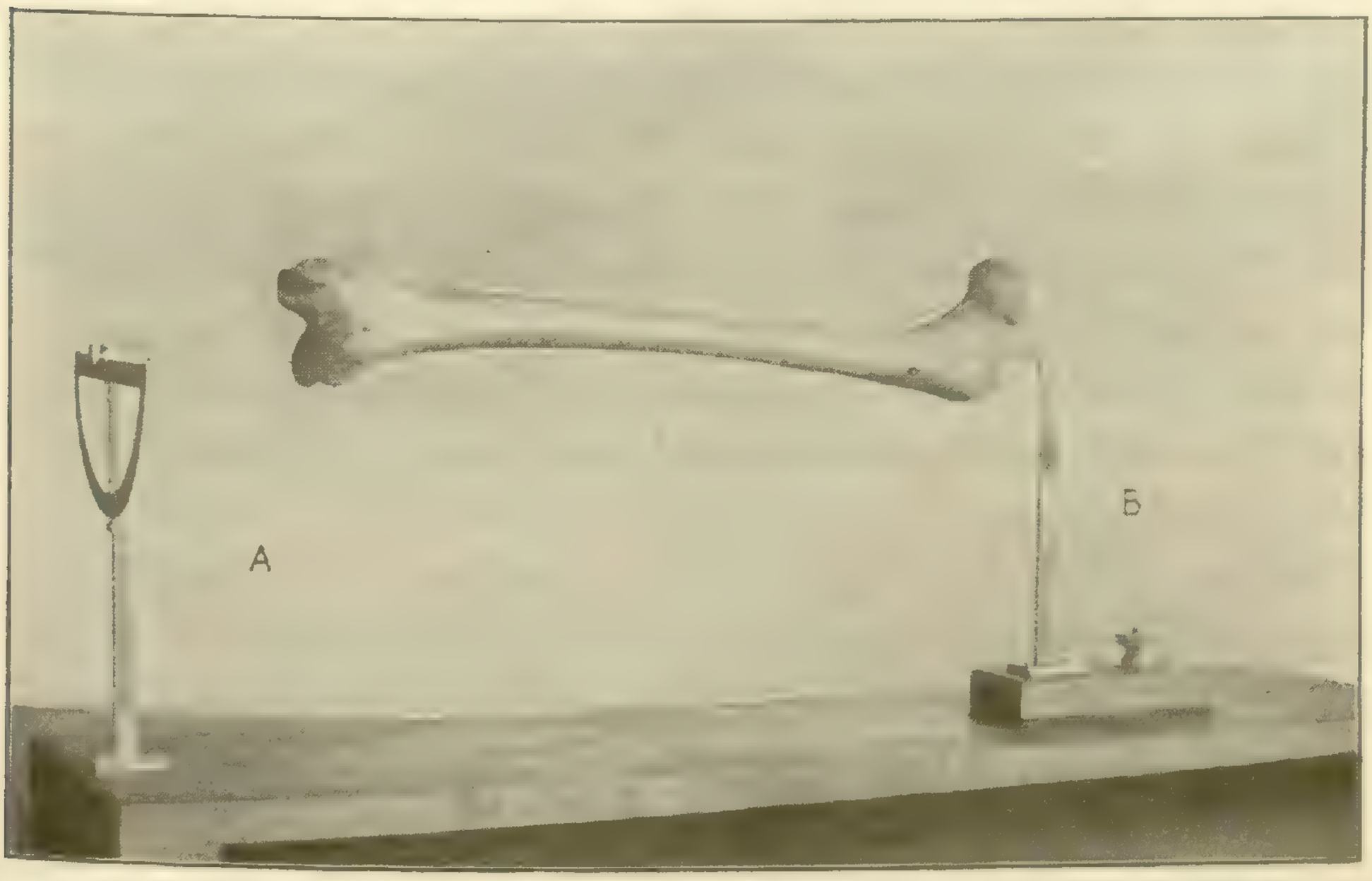
A NEW INSTRUMENT FOR MEASURING TORSION.[1]

FRANK RUSSELL.

THE apparatus that has heretofore been used to measure the torsion of the long bones of the human skeleton has been so difficult of manipulation as to be impracticable. The following description of a simpler apparatus is offered in the hope that it may prove useful to those who are interested in statistical somatology.

The base is 7 by 30 inches; it is grooved for a distance of 14 inches from the middle to within 2 inches of the right end. The post *A*, 8 inches high, is fixed to the base, and has a spur



projecting 3¼ inches toward the right. An ordinary brass protractor is attached to the top of the post at right angles to the spur. (A protractor with the figures reversed in position would be better.) The center of the protractor is fixed at the axis of the spur, on which is pivoted a U-shaped needle that

[1] Demonstrated at the winter meeting of Section H of the American Association for the Advancement of Science, at Baltimore, Dec. 27, 1900.

rises 3½ inches above the spur and extends downward externally to the protractor scale. The right end of the needle should terminate in an eye, through which the spur passes ; the figure represents the trial needle not thus arranged.

The post *B* is movable ; its base slides in the groove of the base board and is held in position by a thumbscrew. The top is provided with a strip of steel 3 inches in length. The strip is provided with saw teeth that engage the head and great trochanter of the femur at the same time (or both condyles), for it is pivoted at its center and stands in the plane of the long axis of the bone. This strip is fixed in an exactly vertical position, and the protractor is exactly horizontal in relation to it.

The torsion of any long bones can be measured with this instrument. The axis of each end is first indicated in pencil; the spur of the post *A* is then engaged with the lower portion of the axial line at one end of the bone; the post *B* is pushed to the left until the strip of steel is in contact with the axial line of that end of the bone. With the left hand the needle on post *A* is adjusted so that the arms are in the plane of the axis of the left end of the bone, the end of the needle points to the degree of torsion on the protractor.

The operation can be performed rapidly and with accuracy. As the bone can be turned end for end and remeasured in other positions, we have a ready means of making control measurements. In practice I have not found it necessary to use any support for even fragile bones, but to insure against accident to such material it is advisable, perhaps, to have a narrow table between the posts of the apparatus, which will not support the bone but simply prevent its falling far enough to injure it.

The apparatus can be made by any skilled mechanic. The model figured here was made for me by a graduate student of anthropology, Mr. W. C. Farabee, at Harvard University.

PEABODY MUSEUM OF
AMERICAN ARCHÆOLOGY AND ETHNOLOGY.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XIV. The Hydromedusæ — Part I.

CHARLES W. HARGITT.

Introductory.

The following synopsis was undertaken more than a year ago as a section of the "Synopses of North-American Invertebrates" now in course of publication. Various interruptions have delayed its completion at an earlier date.

While compiled largely from the author's notes and observations made upon the Hydrozoa of the Atlantic coast during a period of more than ten years, the form and method of presentation are patterned after the systematic works of Hincks, Allman, Haeckel, and von Lendenfeld. For many of the descriptive notes recourse has been had to L. Agassiz's *Contributions to the Natural History of the United States* and to A. Agassiz's *Catalog of the Acalephæ of North America*, as well as to those of the authors just named.

The synopsis is confessedly incomplete in several of the orders, specially upon the Campanularidæ and Leptomedusæ. It is, moreover, limited to a comparatively small range of hydrozoan life of American waters, chiefly of the northeastern Atlantic coast. Of that of the Pacific coast our present knowledge is still too limited to warrant even a provisional synopsis.

The Hydromedusæ comprise one of the three generally recognized classes of Cœlentera, of which the others are the Scyphomedusæ and Anthozoa. While the first two classes have been regarded as much more intimately related phylogenetically than has the third, it may be doubted whether after all their relation may not be quite remote, at least so much so as to warrant separate consideration. Hence slight, if any, reference

will be made to the Scyphomedusæ in considering possible relationships or phylogeny among the Hydromedusæ.

The Hydromedusæ may be distinguished by the following somewhat broad characteristics. In typical cases there is a more or less well marked alternation of generations, *i.e.*, a non-sexual, hydroid stage and a sexual, medusoid, stage. The latter are derived by a process of budding from the stem or hydranth of the hydroid as gonophores which may become free as medusæ or may exhibit varying phases of degeneration as medusoids or mere sporosacs, as in Clava, Campanularia, etc.

In many cases there may be exhibited proliferous medusæ from various portions of the parent medusa, as in Hybocodon. In rare cases one or other of these phases may be entirely lacking, as in Hydra, in which the medusa phase is wholly absent, or as in Rhegmatodes and many others the hydroid stage is apparently lacking.

Perhaps in no phylum of the animal world is there a more striking exhibition of polymorphism than among the Hydromedusæ. This seems to reach its climax in the Siphonophora, though in such forms as Hydractinia it is also evident.

In general the hydroid exhibits a sedentary habit quite in contrast with the free-swimming habit of the medusa. But here again are numerous exceptions. Hydra is capable of locomotion, as are also other hydroid forms, while as already indicated many medusæ are sessile and degenerate, and in the Siphonophora the entire polymorphic colony is free-swimming. In general the hydroids are colonial though with notable exceptions, as in Hydra and many others. While in general form the hydroid and medusoid present rather striking morphological differences, they may yet be reduced to a common and fundamental likeness. Both are of diploblastic structure, having a definite ectoblast and entoblast separated by a middle lamella, or mesogloea, which is a delicate, structureless membrane in the hydroid and in the medusa a rather massive, gelatinous structure, making up the bulk of the body and giving it the characteristic glassy appearance.

In the absence of definite knowledge concerning details of the life history of many of the Hydromedusæ, it is as yet

impossible to formulate any scheme of classification which shall bring into a single view the complete ontogenetic relations of the various hydroid and medusoid phases. In the present synopsis I have followed in the main that of Allman and Hincks for the hydroids and that of Haeckel for the medusæ, though in each there is not a little variation both as to the order of presentation as well as the nomenclature used.[1]

SYNOPSIS OF ORDERS OF HYDROMEDUSÆ.

I. Hydrariæ.

Polyps solitary, never forming colonies; no medusoids; sex-cells produced in ectoderm of polyps.

Of this order only a single well-defined genus is recognized, Hydra. The genera Protohydra and Microhydra are probably allied genera, but their affinities are too uncertain as yet to warrant definite classification. The former is of marine habit, the latter of fresh-water habit. Both are devoid of tentacles, and sexual reproduction, at least in the former, seems unknown.

Of the genus Hydra there are two well-distinguished species: *H. fusca* and *H. viridis*. Both abound in fresh waters of small lakes, ponds, and sluggish streams, associated with various aquatic plants, notably Lemna, various algæ, pond lilies, etc.

II. Hydrocorallinæ.

Colonial. Hydrosome comprising polyps of two forms, gastrozoids and dactylozoids, supported from a network of cœnosarcal hydrorhizæ, from the ectoderm of which is secreted a calcareous mass which is deposited over the spaces or meshes of the network. The colonies form incrusting, often arborescent, masses over shells, stems of Alcyonaria, or other support, often forming massive and fantastic shapes, as in the so-called "stag's horn coral." Only one genus is likely to come within the range of the present synopsis, namely, Millepora; and of this a single species, alcicornis.

III. Tubulariæ (Gymnoblastea).

The Tubulariæ are for the most part colonial hydroids, producing free medusæ, or medusoid gonophores, by budding. Hydroids devoid of

[1] Just as these notes were being put into final form for the press, I have been permitted to consult the manuscript of a forthcoming *Handbook of the Hydroida of the Woods Hole Region*, by Professor C. C. Nutting, for the privilege of which I am under grateful obligations.

hydrothecæ and gonangia. Sexual individuals when set free are known as Anthomedusæ. Medusæ ocellate, *i.e.*, the sensory bodies, are visual in character, and are located usually at the bases of the tentacles. Gonads borne in the tissues of the manubrium.

IV. CAMPANULARIÆ (Calyptoblastea).

Hydroids with hydrothecæ and gonangia. Colonial; propagating by budding both in development of hydrosome and in formation of gonosomes, the latter of which may become free as medusæ, or only partially develop as medusoids, with only rudimentary medusan organs. Medusæ with sensory organs of the vesiculate type, otocysts, borne upon the margin of the bell, usually between bases of tentacles. Gonads borne under the radial canals. Medusæ when free are Leptomedusæ.

V. TRACHOMEDUSÆ.

Hydromedusæ devoid of hydrosome (hypogenic), medusa developing directly from the egg; no alternation of generations known. Sensory organs chiefly tentaculocysts, containing endodermal otoliths. Gonads borne under radial canals. Medusæ generally somewhat hemispherical in shape, with thick mesoglœa. Radial canals, four, six, or eight, often centripetal.

VI. NARCOMEDUSÆ.

Hydromedusæ devoid of hydrosome (hypogenic), development of medusa being direct with no alternation of generations. Medusa rather flat in shape, and with radial canals in form of broad gastric pouches, which vary in number, as do also the tentacles, which are usually set at some distance up on the outer surface of the umbrella.

VII. SIPHONOPHORA.

Hydromedusæ with free-swimming, polymorphic colonies, produced by differential budding. The colonies of this order are characterized by an extreme specialization of the several types of individuals which comprise them. Reproductive products borne in gonophores which seldom become free.

KEY TO FAMILIES OF TUBULARIÆ.

Hydranth devoid of specialized receptacles, hydrothecæ. Sexual products not borne in closed gonangia.

1. Hydranths with scattered, filiform tentacles . . . . CLAVIDÆ, 1
2. Hydranths with single whorl of filiform tentacles:
   a. Hypostome conical, not abruptly differentiated.
      b. Colony regularly branched . . . . . BOUGAINVILLIDÆ, 3

b'. Colony not branched. Hydrorhiza of anastomosing canals, forming an incrusting base, overlaid with ectodermal cœnosarc.
c. Hydranths with sessile, fixed gonophores . HYDRACTINIDÆ, 5
c'. Hydranths producing free medusæ . . . PODOCORYNIDÆ, 6
a'. Hypostome trumpet-shaped or hemispherical . . EUDENDRIDÆ, 4

3. Hydranths with more than a single whorl of filiform tentacles:
a. Stem provided with definite sheath of horny perisarc.
b. Distal tentacles in two whorls . . . . . HYBOCODONIDÆ, 10
b'. Distal tentacles not in two whorls . . . . . TUBULARIDÆ, 9
a'. Stem not provided with definite sheath of perisarc, more or less definitely marked with longitudinal flutings or cœnosarcal channels CORYMORPHIDÆ, 8

4. Hydranths with scattered, somewhat spirally disposed, capitate tentacles only . . . . . CORYNIDÆ, 2

5. Hydranths with proximal circle of filiform tentacles, and with distal capitate tentacles on hypostome . . . . . PENNARIDÆ, 7

1. CLAVIDÆ.

Colonial, stems simple or branching, hydranths elongate, clavate, with numerous filiform tentacles irregularly disposed over the body. Gonophores borne upon hydranth, or on special branches, or occasionally arising from the hydrorhiza. Medusoids never free.

GENERA.

1. CLAVA. Colony of simple, unbranched individuals, devoid of perisarc, except near the base.

2. RHIZOGETON. Colony very similar to Clava. Gonophores arising from hydrorhiza.

3. CORDYLOPHORA. Colony profusely branched and with definite sheath of perisarc.

Clava leptostyla Ag.

Trophosome: Hydranths simple, with slender basal portion which arises from a filiform hydrorhiza protected by a delicate perisarcal covering, which extends slightly upon the bases of the polyps. Tentacles numerous, filiform, and scattered over the hydranth.

FIG. 1.—*Clava leptostyla* Ag. (Adapted from Allman.)

Gonosome: Gonophores in clusters at base of tentacles, medusoids never becoming free. Male gonads of a bright pinkish hue, similar, in general, to that of the colony. Female gonads of a rather distinctly purple color.

Habitat: Shallower waters on fucus, docks, sea wall, etc., at Cold Spring Harbor, Woods Holl, Hadley Harbor, etc.

Rhizogeton fusiformis Ag.

(*Contr. Nat. Hist. U. S.*, vol. iv.)

Trophosome: Colony much as in Clava. Hydranths of about ¼ inch in height, tentacles about twelve in number, borne on distal half of polyp.

Gonosome: Gonophores oval, arising from hydrorhiza on short peduncles, the whole invested by filmy perisarc.

Habitat: Rocky pools between tide marks, Massachusetts Bay.

Cordylophora lacustris Allman.

Trophosome: Colonial, profusely branching, hydranths with scattered filiform tentacles.

Gonosome: Gonophores borne on branches, ovate and with definite investment of perisarc.

Habitat: Brackish, and fresh waters in lagoons, ponds, etc.

FIG. 2.—*Syncoryne mirabilis* Ag. (After Agassiz.)

2. CORYNIDÆ.

Colonial, hydranths with capitate tentacles only, scattered over the elongated bodies, or growing in indefinite whorls. Gonophores usually borne among the proximal tentacles, or from body of polyp and producing medusæ, which may become free or remain attached.

GENERA.

1. SYNCORYNE. Stem invested by definite perisarc; hydranths claviform.

2. CORYNITIS. Stem devoid of definite perisarc; hydranths sessile, with long, cylindrical bodies.

Syncoryne mirabilis Ag.

Trophosome: Branched, perisarc smooth or with only slight indication of annulations. Hydranths with numerous capitate tentacles.

Gonosome: Medusæ borne on hydranth body. These are of two forms, one free and developing earlier, hemispherical, with well-developed tentacles, with an ocellus at their base; the other fixed, tentacles rudimentary, and devoid of ocelli.

Corynitis agassizii McCr.

Trophosome: Colonial, not branched, hydranths with cylindrical, highly contractile bodies, and spirally arranged, capitate tentacles.

Gonosome: Gonophores growing low on body of hydranth or among the proximal tentacles. Medusæ almost spherical, the surface dotted with clusters of nematocysts. Marginal tentacles two or four, nodulated and swollen with batteries of nematocysts.

Habitat: Shells of Mytilis, usually overgrown with incrustations of Membranopora.

3. Bougainvillidæ.

Colonial, branching, with distinct perisarc. Hydranths with conical hypostome and a single whorl of filiform tentacles. Gonophores borne just below the hydranth. Medusæ with four radial canals, marginal tentacles either single or in clusters, and with ocelli at their bases.

GENERA.

1. Bougainvillia. Hydrocaulus with dense perisarc. Medusæ with clustered marginal tentacles and with branching oral tentacles.

2. Perigonimus. Stems with gelatinous perisarc. Medusæ with two marginal tentacles and without oral tentacles.

Bougainvillia superciliaris Ag.

Trophosome: Colony attaining a height of about two inches. Stem irregularly branched, branches annulated proximally. Hydranths with inconspicuous hypostome and from fifteen to twenty tentacles.

Fig. 3. — *Bougainvillia superciliaris* Ag. (After Agassiz.)

Gonosome: Gonophores borne mostly on pedicels from ultimate branches. Mature medusæ with heavy manubrium and branched tentacles, those of margin arising from conspicuous sensory bulbs. Colony light color with greenish tinge, hydranth light rose tint. Medusæ with yellowish manubrium tipped with red, sensory bulbs reddish orange.

Bougainvillia (Margelis) carolinensis McCr.

Trophosome: Colony sometimes eight to twelve inches high, usually much smaller. Stem profusely branching, with hydranths freely distributed on both stem and branches, and of elongate and flexible, subconical form. Tentacles about twelve.

Gonosome: Gonads borne on both stem and branches, often in clusters.

Medusæ much as in previous species, but with narrower and shorter hypostome. Colony light grayish tinged with dull green, hydranths with reddish tint. Medusæ with brick-red manubrium and sensory bulbs, ocelli black.

Habitat: Piles of docks, occasionally on seaweed and floating timbers.

Perigonimus.

Colonial, rarely attaining a height of more than ½ of an inch, simple or branched, perisarc usually gelatinous and extending to base of tentacles. Hydranths relatively large and with conical hypostome. Medusæ borne on hydranths or on stem or branches, bell-shaped and with two to four tentacles with bulbous bases.

Perigonimus jonesii.

(*American Naturalist*, vol. xxviii, p. 27.)

Trophosome: Colonial, branching freely, with thick, gelatinous perisarc, often wrinkled, extending to, or even including, the bases of tentacles. Hydranths with subconical hypostome, with about sixteen filiform tentacles, alternately elevated and depressed.

FIG. 4.—*Perigonimus jonesii.*

Gonosome: Medusæ ovoid or hemispherical, with four radial canals and ocelli, but having only two tentacles, which are often spirally coiled and disposed within the subumbrellar cavity.

Habitat: Found only upon the abdomen and legs of the spider crab, *Labinia marginata*, Cold Spring Harbor, L. I.

4. EUDENDRIDÆ.

Colonial, often branching with great profusion, becoming quite arborescent. Perisarc distinct, more or less annulated, attached by creeping hydrorhiza. Hydranths flask-shaped, with sharply differentiated, trumpet-shaped hypostome. Tentacles filiform, forming a single whorl about the base of the hydranth. Male gonophores borne in a verticil just beneath the tentacles of hydranth, which in some species become directly metamorphosed into gonophores. Female gonophores not verticillate, usually borne on body of hydranth, which often becomes transformed into gonophores with their peculiar spadiceous, finger-like coils enclosing the ova. The family includes a single genus, Eudendrium, fairly characterized in the accompanying cut. The following species are designated:

Eudendrium ramosum Linn.

Trophosome: Colony arborescent, much branched, attaining a height of from four to six inches. Branches rather symmetrical, pinnate and somewhat alternate, with similar sub-branches. Hydranths somewhat ovoid, with trumpet-shaped hypostome, and with single verticil of about twenty tentacles, some of which are often atrophied in male.

Gonosome: Sexes distinct, though often growing in approximate colonies. Gonophores of female somewhat pyriform and scattered, springing from body of hydranth or occasionally directly from stem. Male gonophores spring from base of hydranth close beneath the tentacles in moniliform clusters, each from three to four chambered. Color of male reddish, of female orange. Abundant on piles of docks, on racks, etc., in shallower waters.

FIG. 5.
Eudendrium ramosum Linn.
(After Allman.)

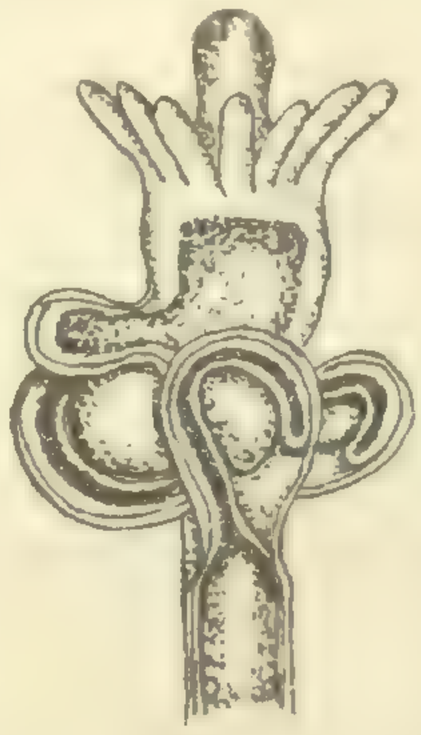


FIG. 6.

FIG. 5.—Colony.
FIG. 6.—Hydranth with gonophores.

Eudendrium dispar Ag.

(*Cont. Nat. Hist. U. S.*, vol. iv.)

Trophosome: Colony large, from three to five inches in height, stems more slender than in former, somewhat fascicled, extensively and variously branched and annulated. Hydranths vasiform, with about twenty-eight tentacles.

Gonosome: Sexes distinct. Gonophores of female of pinkish orange hue, variously clustered about the base of the more or less atrophied hydranth and from distal portion of stem. Habitat in deeper waters in Vineyard Sound, attached to rocks, shells, etc.

Eudendrium tenue A. Ag.

(*No. Am. Acalephæ*, p. 160.)

Trophosome: Colony very small, rarely exceeding an inch in height, branching irregularly, hydranths vasiform, borne on slender pedicels.

Gonosome: Male gonophores from two to four chambered, of pinkish color, clustered from bases of tentacles. Female gonophores bright orange in color, scattered over the branches and stem. Habitat on seaweed, etc., in shallower waters. Not abundant.

Eudendrium capillare Alder.

Of the distinctness of this species and *E. album*, listed by Professor Nutting, I have grave doubts. It seems to me that Alder's diagnosis of capillare coincides so closely with that of *E. tenue* as to render their identity highly probable. So also of *E. album*. Specimens taken at Woods Holl seem almost certainly identical with *E. tenue*, and therefore both should probably be merged under *E. capillare*, whatever slight differences there are being hardly greater than varied environment would easily explain.

5. HYDRACTINIDÆ.

The Hydractinidæ are so closely allied to the following family that it seems unfortunate that they were not originally merged; the only easily distinguishable difference being in the free medusæ of the latter in contrast with the fixed sporosacs of the former. In size, general habit, and morphology they are so closely identical that but for the gonosomes no difference would be recognizable, though in Podocoryne the hydrorhiza seems less definitely covered with naked cœnosarc, — but even this differs greatly in specimens from different localities.

In both polymorphism is a marked feature, at least three types of polyps being distinguishable:

1. Feeding hydranths (trophopolyps), whitish in color and with numerous filiform tentacles, frequently appearing in alternately elevated and depressed order.

2. Reproductive individuals (gonopolyps), more slender-bearing gonophores in clusters below the tentacles, which are fewer in number than in the first and imperfectly developed.

3. Spiral polyps, elongated individuals, wholly devoid of tentacles and with apex of body thickly beset with nematocysts.

The entire colony arises from an incrusting base which is thickly beset with jagged spines, the latter sometimes considered a fourth type of individual.

FIG. 7. — *Hydractinia echinata*.
(Adapted from Hincks.)

Hydractinia echinata Fleming.

(Hydractinia polyclina Ag., *Cont. Nat. Hist. U. S.*)

Trophosome: Colony composed of numerous polyps, as given above.

Gonosome: Gonads as sessile sporosacs borne on distinct hydranths, gonopolyps, having but few tentacles. Medusoids never free.

Habitat: Usually found upon shells occupied by the hermit crab, but occasionally found upon fucus and occasionally also upon piles of docks.

6. Podocorynidæ.

Colony very similar to that of the Hydractinidæ, as given above. Hydranths with single whorl of filiform tentacles surrounding base of the conical hypostome.

Podocoryne carnea Sars.

Trophosome: Hydranths slender, pinkish-white in color, and with filiform tentacles.

Gonosome: Medusæ borne in clusters about the hydranth just below the whorl of tentacles. When set free the medusa is of marked bell-shape, with definite velum, short manubrium of reddish color, four radial canals from the bases of which arise eight marginal tentacles.

Habitat as in Hydractinia.

Stylactis.

Under this generic name Sigerfoos describes (*American Naturalist*, Vol. XXXIII) a hydroid having many points in common with the Podocorynidæ, and it should probably be classed under this family. He has given to it the specific name Hooperi (*cf. op. cit.*). The following definitive characters have been given of it:

Trophosome: Hydranths slender, with a length when fully expanded of about ¾ of an inch. Tentacles in single whorl, filiform, and of variable number, eighteen to twenty-five.

Gonosome: Gonophores borne upon specialized hydranths just below tentacles, and set free as medusæ having four radial canals, eight tentacles which are somewhat rudimentary, devoid of ocelli. Sexual products borne upon manubrium. Found on shells of *Stygnassa* (Illyanassa) *obsoleta*.

7. Pennaridæ.

Colony arborescent, pinnately branched, hydranths with two sets of tentacles, one proximal composed of ten to twelve, filiform, the other borne upon hypostome in two indefinite whorls, short and capitate.

Pennaria tiarella McCrady.

Trophosome: Colony attaining a height of from five to six inches, usually smaller in colonies attached to eelgrass or seaweed. Regularly branching, stem somewhat undulating, or geniculate in young colonies, regularly annulated just above branches, as are also the latter at point of origin. Hydranths large and flask-shaped, those terminating stem or branches appreciably larger than others.

Gonosome: Medusæ borne on hydranth body above the whorl of proximal tentacles. Medusæ liberated during early evening and discharging the sex products immediately thereafter. In many cases the ova are discharged before the liberation of the medusæ, as indeed are also the sperms.

Habitat: Abundant on piles of docks, floating timber, eelgrass, fucus, etc., usually in shallower waters. Development from June to October.

8. CORYMORPHIDÆ.

Usually solitary, though I have occasionally found definite colonial buds arising direct from the hydrorhiza. Hydranths with proximal and distal whorls of filiform tentacles. Gonophores as free medusæ with four radial canals and with one to four marginal tentacles, one of which is usually much the larger.

FIG. 8.

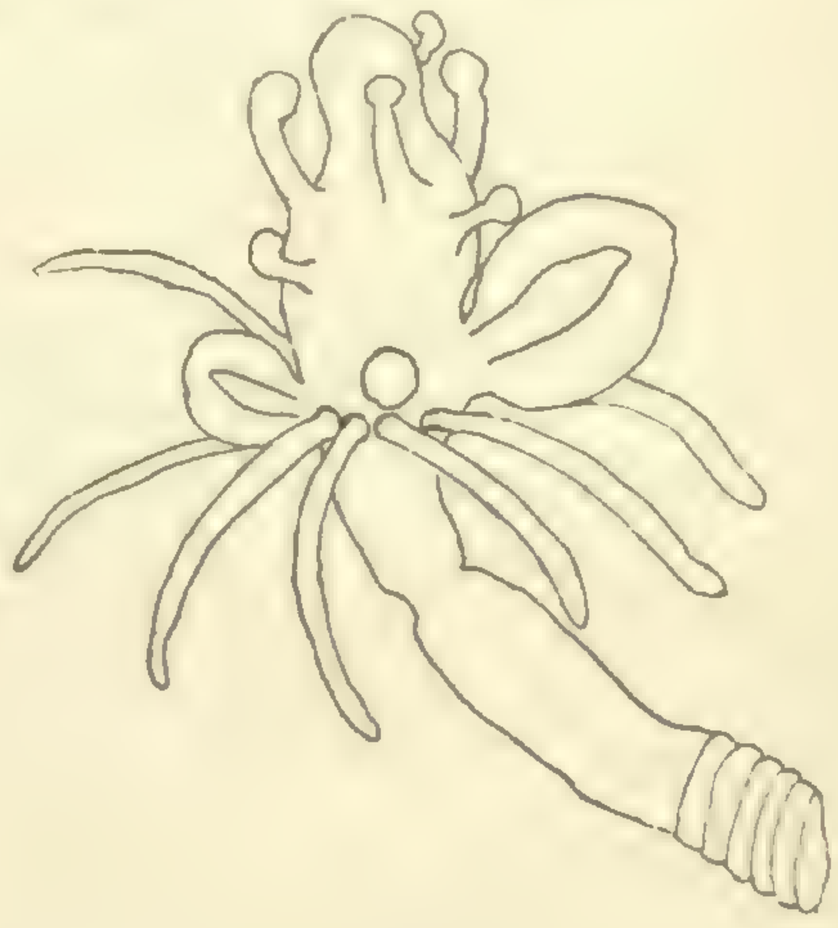


FIG. 9.

FIG. 8. — *Pennaria tiarella* McCr.
FIG. 9. — Hydranth enlarged, showing origin of medusæ.

Corymorpha pendula Ag.

(*Cont. Nat. Hist. U. S.*, vol. iv.)

Trophosome: Hydrocaulus from two to four inches in height, the fleshy cœnosarc traversed by longitudinal canals which ramify more or less near the base. Hydrorhiza an indefinite root-like expansion of the base, by which the whole is attached to the sandy substratum.

Hydranths flask-shaped, sharply distinct from stem. Proximal tentacles large, forming a single whorl at base of hydranth. Distal tentacles very contractile, forming alternating verticils about the base of the hypostome.

Gonosome: Medusæ borne on branched peduncles, arising just above the proximal tentacles, ovoid hemispherical, with single large and usually three rudimentary tentacles.

Hydroid bright pink in color, medusæ light yellowish, manubrium, tentacles, and bulbs pinkish.

Habitat: Sandy bottom in rather deep waters at various points in Vineyard Sound, Muskegat Channel, etc.

9. TUBULARIDÆ.

Hydrocaulus with definite perisarc, simple or irregularly branched. Hydranths flask-shaped, with proximal and distal whorls of filiform tentacles. Gonophores in form of fixed sporosacs, borne on branched peduncles.

Tubularia.

Generic description as given for family. The following species are given:

Tubularia couthouyi Ag.

(*Cont. Nat. Hist. U. S.*, vol. iv.)

FIG. 10.—*Corymorpha pendula* Ag. (Modified from Allman.)

Trophosome: Stems unbranched, attaining a height of from four to six inches. Hydranths large, often expanding an inch or more in diameter, with proximal whorl of thirty to forty filiform tentacles and a distal one of much smaller.

Gonosome: Gonophores as numerous, densely crowded racemes of pendulous sporosacs. Larvæ escaping as actinulæ. Hydranth and gonads bright pinkish red.

Habitat: On sandy bottoms dredged off Nobska Point, Vineyard Sound, and other similar places in the same locality.

Tubularia larynx Ellis and Solander.

Trophosome: Stems clustered, more or less branched, annulated. Height one to two inches. Stem forming a collar-like expansion just below hydranth, the latter bearing sixteen to twenty proximal filiform tentacles and a distal whorl of about the same number.

Gonosome: Gonads in pendulous clusters, similar to last. Color of hydranth and gonads rosy. Perisarc yellowish.

Tubularia spectabilis Ag.

(*Thamnocnidia spectabilis* Ag., *Cont. Nat. Hist. U. S.*)

Trophosome: Colony irregularly branched and sparsely annulated. Height three to four inches. Hydranths much as in former.

Gonosome: Comparable with former.

Tubularia tenella Ag.

(*Thamnocnidia tenella* Ag.)

Trophosome: Colony very small, rarely exceeding a height of one and one-half inches. Stem loosely branched and with indefinite annulations. Hydranths with tentacles about as in former.

Gonosome: Compare *T. larynx*. Color and habitat much as in last.

FIG. 11. — *Tubularia tenella* Ag.

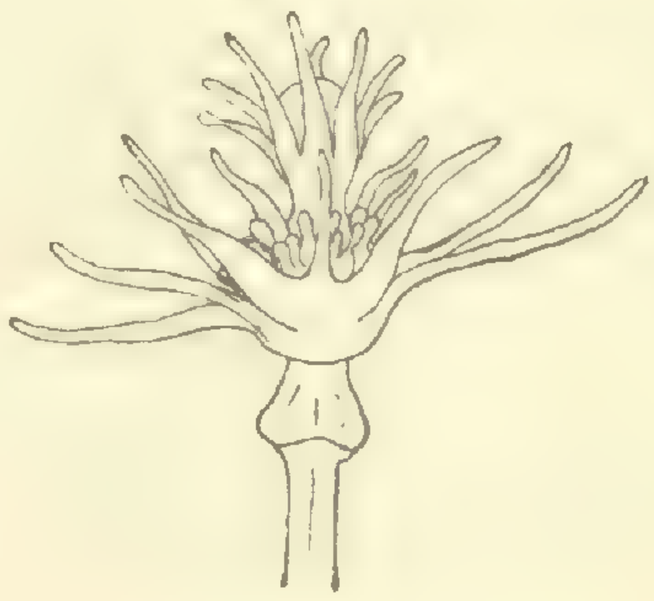


FIG. 12. — Single hydranth enlarged. (After Agassiz.)

FIG. 13. — *Tubularia crocea* Ag.

FIG. 14. — Hydranth with pendulous gonophores.

Tubularia crocea Ag.

(Parypha crocea Ag.)

Trophosome: Colonies growing in dense tufts of tangled stems of from three to four inches in height. Stems sparingly branched, with occasional indications of annulations. Hydranths with tentacles much as in former species, but numbering from twenty to twenty-four in each whorl.

Gonosome: Much as in the first species. Hydranths and gonads of rosy-red color, stem pale, whitish. Habitat. Growing in dense masses on piles of docks, floating timbers in harbors, and shallower waters.

Hypolitis perigrinus Murbach.

Under this name Murbach describes a hydroid taken at Woods Holl (*Quar. Journ. Mic. Sci.*, Vol. XLII), which would seem to have some affinities with the Tubularidæ. The following characters are summarized:

Trophosome: Colony consisting of simple hydranths with long hypostome and with distal and proximal whorls of filiform tentacles. Polyp free.

Gonosome: Gonads borne on hypostome just above proximal tentacles and occur singly in the type specimen. Sessile medusoids, somewhat terete in form and devoid of tentacular processes.

10. Hybocodonidæ.

Hydrocaulus unbranched, solitary, with definite perisarc and hydrorhiza. Hydranths large, with proximal and two distal whorls of filiform tentacles.

Fig. 15. — *Hybocodon prolifer* Ag. (After Agassiz.)

Hybocodon prolifer Ag.

(*Cont. Nat. Hist. U. S.*, vol. iv.)

Trophosome: Stems longitudinally striated, occasioned by cœnosarcal canals. Perisarc enlarged and annulated just below hydranth. Hydranth similar to those of the Tubularidæ, but with oral tentacles in two distinct whorls.

Gonosome: Gonophores closely attached to hydranth body just above proximal tentacles. Free medusæ with four radial canals, and with a single greatly enlarged tentacle from whose base a number of secondary medusæ successively bud, and from these still other groups of similar medusæ may arise.

Syracuse University.

REVIEWS OF RECENT LITERATURE.

ZÖOLOGY.

Jordan and Snyder on Japanese Fishes. — In the *Proceedings of the United States National Museum* (XIII, 335), Jordan and Snyder give a list of the fishes collected in Japan by Professor Keinosuke Otaki in 1895 and 1896, and by the "Albatross" in 1896, these collections being in the Museum of Stanford University and the United States National Museum. Fourteen species are described as new and most of them figured by Mrs. Starks. These are *Chimæra phantasma*, *Gobio biwæ*, *Gobio mayedæ*, *Otakia rasborina*, *Congrellus meeki*, *Pseudolithus mitsukurii*, *Sebastodes hakodatis*, *Sebastodes scythropus*, *Scorpæna onaria*, *Callionymus beniteguri*, *Trifissus ioturus*, *Blennius yatabei*, *Cœlorhynchus kishinouyei*, and *Verasper otakii*. The species last named is probably not distinct from *Verasper grigorjewi*, lately described as a species of Hippoglossus from Hakodate by Herzenstein. The manuscript name of *Lampetra mitsukurii* Hatta is adopted for the small lamprey of southern Japan.

In the list of Japanese fishes the following new genera are indicated: *Ishikauia* (*steenackeri*), *Otakia* (*rasborina*), *Konosirus* (*punctatus*), *Bryttosus* (*kawamebari*), *Corusculus* (*Anthias berycoides*), *Eteliscus* (*Etelis berycoides*), *Insidiator* (*rudis*), *Trifissus* (*ioturus*), *Rhombiscus* (*cinnamomeus*), *Karcius* (*bicoloratus* = *scutifer*), *Usinosita* (*japonica*), *Zebrias* (*zebrina*), *Areliscus* (*joyneri*).

The two species referred to Gobio belong rather to Günther's genus Leucogobio. The specimens called *Apogon quadrifasciatus* belong to *Apogon notatus* (Houttuyn) = *semilineatus* Schlegel. Those recorded as *Sebastodes oblongus* belong to *S. mitsukurii* Cramer, which differs in the larger scales. The species recorded as *Chænogobius castaneus* is distinct from the latter species and is as yet undescribed. The genus Triænophorichthys, as Steindachner has shown, is identical with Tridentiger, and Trifissus is not different. In fact, later investigations show the identity of *Trifissus ioturus* with Steindachner's *Tridentiger bifasciatus*. D. S. J.

Fowler on Fishes of the Tropical Pacific. — In the *Proceedings of the Academy of Natural Sciences at Philadelphia* (1900, p. 493) Mr. Henry

W. Fowler gives a detailed account of fishes from Hawaii, Tahiti, and Samoa, in the collection of the Academy. Most of these were collected more than sixty years ago by the noted naturalists, Dr. John K. Townsend and Mr. Thomas Nuttall. Others were more recently obtained by Dr. William H. Jones and Dr. Benjamin Sharp.

The new species are the following. From Honolulu: *Lycodontis parvibranchialis*, *Echidna zonata*, *Stolephorus purpureus*, *Synodus sharpi*, *Hemipteronotus copei*, *Brotula townsendi;* from Samoa, *Mugil caldwelli.*

Mr. Fowler is very careful as to his nomenclature and synonymy, a sure sign of good workmanship in systematic zoölogy, and his conclusions seem everywhere tenable. The plates which illustrate Mr. Fowler's paper, eleven species in all, seem accurately drawn, but are not well reproduced.

It may be here noted that the name Stolephorus cannot be used for the great genus of anchovies, to which it has been of late years (following Bleeker) applied. Its type, *Atherina japonica* of Houttuyn, from Nagasaki, is not an anchovy, but the very common Japanese silver-sided sardine, Kibuna-iwashi, commonly known as *Spratelloides gracilis*. Stolephorus should therefore supersede Spratelloides. The genus of anchovies called Stolephorus should probably stand as Anchovia. The single species which Jordan and Evermann set apart under the latter name is probably not generically distinct. Perhaps all these species should be reunited under Engraulis, following Günther's view. The tropical anchovies have, however, a smaller number of vertebræ and a firmer texture of body than the species originally called Engraulis. I may note also the necessity of returning to Gymnothorax Bloch instead of Lycodontis. D. S. J.

Miall and Hammond's Harlequin Fly.[1] — This is a book about an animal that has figured prominently in histological work for a generation. It is a book that is intended to facilitate the study of Chironomus, especially for inland naturalists, to whom it is so readily available, by setting forth in detail its habits and life history, presenting a résumé of the studies hitherto made of it (chiefly on its salivary glands and its embryology), and adding many new and more or less interesting facts and observations. The chapter headings are as follows: Outline of Life History, and Relations of Chironomus to Other Diptera; the Larva of Chironomus; the Fly of Chironomus;

[1] Miall, L. C., and Hammond, A. R. *The Structure and Life History of the Harlequin Fly* (*Chironomus*). Oxford, The Clarendon Press. 8vo, iv + 196 pp., 129 figures.

The Development of the Pupa and Fly within the Larva; The Pupa of Chironomus; and The Embryonic Development of Chironomus. To this is added a brief appendix on methods, likewise intended to promote the use of Chironomus as a laboratory subject. The numerous figures are well selected and useful, but in their execution the best of them do not rise above mediocrity.

Incidentally there is described (on page 34) and figured the larva of Clinocera (Fam. Empididæ), a new type of dipterous larva with eight pairs of prominent abdominal prolegs. J. G. N.

Reactions of Protozoa. — In the Supplementband for 1900 of the *Archiv für Anatomie und Physiologie*, August Pütter[1] presents a most valuable contribution to our knowledge of the reactions of unicellular organisms. The fact that the reactions of these creatures to various stimuli are profoundly modified when the organism is in contact with a solid, is strikingly evident to any one that has studied the behavior of the Protozoa. Pütter has subjected to a thorough analysis this effect of contact of solids (thigmotaxis) and its interference with the operation of other stimuli, and the results form a contribution, an acquaintance with which is indispensable to all who wish to obtain an understanding of the behavior of these creatures. Exact observation of the actual movements of the organisms, close attention to the interrelation of structure and function, and careful analysis of the various factors involved, form the striking and valuable features of the paper, which stands in refreshing contrast in this respect to some of the recent papers dealing with the reactions of lower organisms. The paper is so full of detail, and casts light on so many observed phenomena, that it is impossible to give an idea of the results in a brief notice. In addition to a precise account of the thigmotactic reaction itself, the author deals particularly with the reactions to heat and to the electric current, as modified by the thigmotactic reaction. The observations on electrotaxis are in accord, in all essentials, with those set forth by Pearl in the *American Journal of Physiology* for July, 1900, and throw some additional light on this subject, especially on the subject of *transverse* electrotaxis. Attention may be further called to the fact that Pütter confirms for many Infusoria the method of reaction to a stimulus by turning toward a structurally defined side, as described by the reviewer.

[1] Pütter, August. Studien über Thigmotaxis bei Protisten, *Archiv für Anatomie und Physiologie*, Physiologische Abteilung, Supplementband, 1900, pp. 243–302.

By the work of Pütter another of the reactions of these organisms — thigmotaxis — is placed on a satisfactory scientific basis, and light is thrown on many other phenomena. H. S. J.

Notes. — Burchardt's recent article (*Jenaische Zeitschrift*, Bd. XXXIV, pp. 719–882) on the body spaces and connective tissue of Amphioxus is of general interest because of the accompanying bibliography, which is intended to be complete for this important and much studied animal. The list is arranged chronologically and includes some six hundred references. One is reminded of Baedeker on finding that important papers are indicated by an asterisk.

Metcalf ("Notes on the Morphology of the Tunicata," *Zoologische Jahrbücher*, Bd. XIII, 1900, pp. 495–602, Heft IV) gives us a paper extending over a wide range of morphological and systematic topics. A brief notice like the present one cannot mention all the results of interest contained in such a paper as this. Among them the following are perhaps the most important: The homology of the vertebrate hypophysis and the neural gland of the Tunicata is a "suggestion the truth of which, while it may be probable, is still insufficiently established." Reëxamination of the structure of the interesting deep-sea genus Octacnemus leads to the conclusion that its affinities are with those simple ascidians that reproduce by budding, rather than with the Salpidae, as supposed by Herdeman. It is proposed to institute a family, the Octacnemidæ, for it. A new species of the molguloid genus Bostrichobranchus, *viz.*, *B. molguloides*, is described.

A contribution to the postembryonal development of Molgula is made by Marc de Selys-Longchamps and D. Damas (*Arch. de Biologie*, Tome XVII, 1900, pp. 385–483). The development of the stigmata is studied with special care. Six pairs of protostigmata are recognized, the first two pairs forming simultaneously. The later multiplication and coiling up of the stigmata and the formation of the infundibulæ are followed out. The larval sense organ is found to persist into adult life in *M. ampulloides*. The study of the development of the sexual glands leads to the conclusion that there is no bilateral symmetry in the disposition of the germinative epithelium.

In studies on some distomes, Jacoby describes (*Arch. f. Naturges.*, Bd. I, 1900) a species, *Distomum heterolecithodes* Braun, which is remarkable for the fact that the vitelline gland, which is usually symmetrical, is developed only on one side of the body. In eleven cases studied the organ was sinistral, while in four the author found

a complete *situs inversus*, or, as Kowalewski has termed it, sexual amphitypy, in which the arrangement of organs is the mirror image of the normal condition. The same anomaly was found to occur in the following species in the ratio given: *Opisthorchis crassiuscula* (Rud.) 7 : 84, *O. poturzycensis* (Kow.) rarely; *O. albida* 16 : 68, *O. truncata* (Rud.) 6 : 50, *O. felinea* (Riv.) 8 : 100. Other cases from other species have been recorded by Stiles and Hassall, and Kowalewski regards it as a characteristic of the genus Opisthorchis. If this be true, it must still be remembered that it may occur in other genera also. Jacoby observed it in *Distomum lanceolatum*, which is not related to Opisthorchis but rather perhaps to *D. heterolecithodes*.

The nervous system of *Moniezia expansa* has been studied by Tower (*Zool. Jahrb.*, Abt. Morph., Bd. XII, pp. 359–384, 6 pls.). It is noteworthy that the physiological salt solution, so universally used, is harmful if the worms remain in it more than an hour. The author gives the formulæ of fluids successfully employed for transporting the cestodes, for keeping them alive in the laboratory even up to five days, and for fixing and staining the nervous tissues. In the scolex is present an anterior nerve ring with four small ganglia opposite the suckers, a pair of large cephalic ganglia connected with the ganglia of the anterior ring by four nerves and surrounded by the posterior ring which connects with the lateral lobes of the cephalic ganglia, and also by four small nerves with the ganglia of the anterior ring. These latter nerves are the beginning of the dorsal and ventral longitudinal nerves, while the prominent lateral nerves spring from the lateral lobes of the cephalic ganglia. No accessory lateral nerves were present. In each proglottid each lateral nerve bears an anterior lateral ganglion near the center and a posterior lateral ganglion near the posterior margin. From the former a transverse genital nerve arises, and from the latter a bunch of smaller fibers, together with a marginal nerve, which is recurrent, and the dorsal and ventral commissures which together constitute the nerve ring of each proglottid.

The Uncinariæ of the Canidæ and Felidæ and the Sclerostominæ of the Ruminants have been subject to a careful revision by Railliet (*Arch. Parasitol.*, Tome III, No. 1, 1900).

The distomes of the isolated genus Rhopalias St. and H. (Rhopalophorus Dies) have been restudied from Rudophi's and Diesing's types by Braun (*Zool. Anzeiger*, Bd. XXIII, pp. 27–29). Three species are reported, of which one is new, and the genus appears to be confined to the marsupials of South America. These forms are closely

related to the echinostomes, but the lateral lobes of the head, which are supplied with spines, have been transformed into a retractile proboscis.

An Atlantic "Palolo" is described by Mayer (*Bull. Mus. Comp. Zool.*, Vol. XXXVI, pp. 1–14, 3 pls.). The form, which is shown to be distinct from the Pacific species of similar name and habits, is named *Staurocephalus gregaricus*. It appeared in a dense swarm before sunrise on a single morning and discharged its sexual products with the coming of the sun under contractions so violent that the ripe segments were torn open. The author gives an interesting discussion of the advantages of this habit in shortening the egg-laying season, concentrating the breeding individuals and not only insuring more perfect fertilization, but also reducing the distance which the sperm must traverse in order to fertilize the ova; while the increased struggle for food due to the production of a large number of young larvæ is counterbalanced by the heavily yolk-laden egg of this species.

The Alciopidæ and Tomopteridæ of the Plankton Expedition by Apstein (*Ergebnisse der Plankton-Expedition der Humboldt-Stiftung*, Bd. II, H. b., 61 pp., 14 pls.) opens with an extended taxonomic account of the alciopids captured. The geographical distribution of these forms has been much extended, as appears from the tables given, which also show that the group belongs to warmer waters, with the exception of strays found in the northern branches of the Gulf Stream and of a single Antarctic species. Within the warm zones they appear to be generally distributed without special areas and are present everywhere in approximately equal numbers, as shown by the hauls of the vertical net. Among the tomopterids, however, a single species seems to occur only in the vicinity of land, though with an extended range, while the others are all true pelagic forms. The genus contains species found in cold waters, — those characteristic of warm regions and such as inhabit both. While moderately equally distributed, these forms do not manifest the uniformity noted for the alciopids.

BOTANY.

Some Recent Forestry Publications. — The interest in the preservation of the timber covering which still characterizes certain parts of the earth, and its renewal in denuded areas, which appears to be

spreading gradually in this country and which has long been recognized as economically important in many other parts of the world, is leading to the rapid appearance of handbooks and other publications, of varying degrees of excellence but all of utility. Notice has been made elsewhere of Mr. Gannett's magnificent treatise on our own forests,[1] which stands in a class quite by itself as a work of rare statistical and other practical value, and of the botanico-forestal books of Professor Sargent[2] and Miss Keeler.[3] The mail now brings an official handbook of Indian forestry, by R. Ribbentrop,[4] and a book by Abbot Kinney,[5] intended to awaken and spread popular interest in this subject on our Pacific coast.

Mr. Ribbentrop, who is Inspector-General of forests to the government of India, traces the history of forestry development in a British colony where, whatever else may be said, the home government has made continuous and intelligent effort to develop and conserve the rich endowment of nature; and the influence of this policy on the native governments is shown to be most encouraging.

Mr. Kinney, who has had ample opportunity to observe the reckless waste of timber in one of the grandest existing forests, analyzes the relations of forest preservation to the elements and the greed or carelessness of man, and presents an outline for a forest system for southern California. A number of specialists contribute chapters to his book on irrigation and the peculiar conditions appertaining to sand dunes. T.

Coulter and Rose's Umbelliferæ. — A revision of the Umbelliferæ of our flora, by Drs. Coulter and Rose,[6] constitutes the opening number of Vol. VII of the *Contributions from the United States National Herbarium*. Three hundred and seventy-one species, pertaining to seventy-eight genera, are included, with necessary

[1] Gannett, H. Forest Reserves, *Ann. Rept. U. S. Geol. Surv.*, Washington, 1900, vol. xx, pt. v. xviii + 498 pp., with numerous maps, charts, and process illustrations from photographs.

[2] Sargent, C. S. *The Silva of North America.* Boston and New York, 1890–1900. Twelve quarto volumes, with many plates, and to be completed in one or two additional volumes now in preparation.

[3] Keeler, H. L. *Our Native Trees and how to Identify Them.* New York, 1900.

[4] Ribbentrop, B. *Forestry in British India.* With a rainfall chart and three maps. ii + 245 pp. Calcutta, 1900.

[5] Kinney, A. *Forest and Water.* v + 247 pp., with numerous diagrams and half-tone plates. Los Angeles, 1900.

[6] Coulter, J. M., and Rose, J. N. Monograph of the North-American Umbelliferæ. vii + 256 pp., Pl. IX, ff. 65. Washington, 1900.

synonymy and description, and the essential fruit characters of the genera are clearly and accurately figured. In pleasing contrast with the habit of some writers, the authors give a full citation of the material that they have examined in the course of their study — on the satisfactory result of which they are to be congratulated.

Studies of Plant Life[1] is a laboratory guide for high schools, which represents the experience of three Chicago teachers. The twenty-four studies it contains, each consisting of directions and questions regarding easily obtainable material, are intended to supplement the botanical lectures or text-book work of a school year. Part I, made up of seventeen studies, deals mainly with Cryptogams; Part II is devoted to the organs of Spermaphytes and their modifications. Much use is made of the compound microscope and of comparatively inexpensive apparatus. In an appendix are given directions for twenty-four experiments illustrating nutrition, metabolism, growth, and irritability. Following this is an outline of a model field trip showing what may be done in the way of ecological study. At the end of the book comes an analytical key for the determination of one hundred seed plants of northeastern United States, which includes a short synopsis of forty-two families of angiosperms.

The book seems well calculated to direct young students along profitable and interesting lines of work, following present-day methods of teaching the "New Botany."

But few errors have been noticed, and these are for the most part such as any competent teacher may be trusted to correct before they are likely to become a source of trouble to pupils. Special attention should be called to the need of amending the study on seeds and seedlings. Here the most unfortunate misconception is the treatment of the maize kernel as a seed, the funiculus and hilum of which the student is expected to find. F. L. S.

Notes. — Professor Engler has issued the first of a series of "Ergänzungshefte" to the phanerogamic portion of Engler and Prantl's *Die Natürlichen Pflanzenfamilien*, containing additions for the years 1897–98. The publication of the regular fascicles of this

[1] Pepoon, Herman S., Mitchell, Walter R., and Maxwell, Fred B. *Studies of Plant Life*, a series of exercises for the study of plants. Boston, D. C. Heath & Co., 1900. 12mo, cloth, xii + 95 pp.

important work has now reached Lieferung 201, dealing with the Hyphomycetes.

"A Taxonomic Study of North-American Ranunculaceæ" is the title under which Dr. K. C. Davis publishes his thesis, submitted to the Faculty of Cornell University last June. It consists of a series of articles separately printed from various journals, some of which have already been noticed in the *Naturalist.*

A posthumous revision of the genus Matthiola, by Pascal Conti, accompanied by a portrait of the author, appears in No. 18 of the *Mémoires de l'Herbier Boissier.*

The Oxalidaceæ of Uruguay receive apparently careful treatment by Arechavaleta in fascicle 14 of the third volume of *Anales del Museo Nacional de Montevideo.* Thirty-five species are described.

A study of the leaf anatomy of the Melastomaceæ constituting the tribe Miconieæ, with reference to the classification of the plants, forms No. 19 of *Mémoires de l'Herbier Boissier.*

Bulletin 175 of the North Carolina Experiment Station contains descriptions of twenty-one species of Cratægus and eight species of Panicum, believed to be new.

Rubus idæus anomalus is reported from Vermont by Fernald in *Rhodora* for October.

Celtis pumila, the separability of which from the arboreous species of the Mississippi valley has long been in dispute, is critically considered, in connection with its allies, by E. J. Hill, in the *Bulletin of the Torrey Club* for September.

The Revue Horticole for October contains an interesting article by Bois on the Mexican forms of *Persea gratissima*, with a colored plate of one of the finer varieties.

The physiological differences between the sessile- and pedunculate-fruited English oaks are considered at some length by W. R. Fisher in the *Gardener's Chronicle* of September 22.

No. 14 of Dr. Holm's "Studies in the Cyperaceæ," in *The American Journal of Science* for October, refers chiefly to a collection of carices made in Alaska by Evans in 1897–98.

Part XIV of Kraenzlin's "Orchidacearum Genera et Species," recently issued, reaches page 896.

A monograph of the Erysiphaceæ, by Ernest S. Salmon, constitutes the ninth volume of *Memoirs of the Torrey Botanical Club*, bearing the date Oct. 4, 1900. Nine plates of details, containing 175 figures and a very full bibliography and host-index, with analytical keys for each genus, make the book easy to use.

A preliminary report on diseases of the red cedar caused by *Polyporus juniperinus* and *P. carneus*, by Dr. Von Schrenk, constitutes *Bulletin No. 21* of the Division of Vegetable Physiology and Pathology of the United States Department of Agriculture. The first of these fungi is described as new. The gelatine process-reproductions of photographic illustrations of the decayed timber are good examples of what may be done in illustration direct from the camera.

Professor Nelson publishes, as a separate from the tenth *Report of the Wyoming Experiment Station*, a preliminary list of the cryptogams of that state, exclusive of Pteridophytes.

An interesting article on the occurrence of mycorrhiza on Arctic plants is reprinted by Hesselman from *Bihang till K. Svenska Vet.-Akad. Handlingar*, Vol. XXVI.

The structure of the diatom girdle is discussed by Palmer and Keeley, in Part II of the current volume of *Proceedings of the Philadelphia Academy*.

Five new species and one variety, chiefly in Allium and Artemisia, are added to the Colorado flora by Osterhout in the September number of the *Bulletin of the Torrey Club*.

Part III of Thomas Howell's *Flora of Northwest America*, dated August 21, 1900, reaches part way through the Compositæ.

A "Botany of Southern California," by Charles Russell Orcutt, is begun in the *West American Scientist* for September.

A considerable number of new species of North-American plants are published by several writers in recent numbers of *Zoe*.

Professor F. Manson Bailey's contributions to the flora of Queensland, New Guinea, etc., continue to appear in current numbers of the *Queensland Agricultural Journal*.

Dr. Carreiro, the most active botanist now resident in the Azores, contributes a list of his recent discoveries to the October-November number of the *Bulletin de l'Académie internationale de geographie botanique*.

Volume VI of the "Flore de France" of Rouy and Foucaud, devoted to Rosaceæ, appears as the 1899 *Annales de l'Académie de La Rochelle*, and is ascribed to Rouy and Camus.

The public school department of Carthage, Mo., where nature study of the most practical kind has taken firm root through the efforts of Professor Stevens, the superintendent, has now begun the publication of a series of "Nature Study Leaflets," dealing with common objects.

Progress in American agriculture and the sciences upon which it rests is well sketched in the voluminous *Yearbook* of the United States Department of Agriculture for 1899, recently issued.

Part IX, recently published, completes the second volume of the *Bulletin of the Bussey Institution*, which has been in progress since the year 1877. A table of contents and an index make the subject-matter of the volume accessible.

Forestry in Sweden is reported on by General Andrews, late United States Minister to that country, in a Senate Document recently issued.

The conditions of success in grafting are discussed by Daniel in current numbers of the *Revue générale de botanique*.

Dr. P. Van Romburgh publishes an important paper on Caoutchouc and Gutta-percha in the Dutch Indies, as No. 39 of the *Mededeelingen* of the Buitenzorg Botanic Garden.

A biographical sketch, with portrait, of Klatt, whose writings on Iris and certain Compositæ are familiar to all working botanists, is reprinted by Voigt from the *Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten* for 1898.

A portrait of the late Sir J. B. Lawes, whose field experiments on the physiology of agricultural plants, extending over many years, are known to all botanists, appears in *Science Gossip* for October.

PALEONTOLOGY.

Traquair's Presidential Address, Bradford, 1900. — The Zoölogical Section of the British Association, in its choice of Dr. Traquair for president, paid a graceful tribute to a scientist whose researches during the past thirty-five years have conduced more

to our knowledge of Paleozoic fishes than those of any other single investigator. And the propriety of electing a paleontologist to preside over its sessions is abundantly confirmed by the brilliant address of sixteen closely printed pages with which its sittings were opened.

In this essay Dr. Traquair has done for the class of fishes what Marsh attempted for American fossil vertebrates in general, and what Osborn accomplished for the Mammalia, in their addresses before the sister association[1] in this country some years ago; and these three summaries, taken together, constitute a very important chapter in the literature of vertebrate paleontology. Although not retrospective in an historical sense, Dr. Traquair's paper is in effect a clarified review, expressed in terms of evolution, of the leading philosophic deductions which the science of ichthyic paleontology has afforded up to the present time. Its significance consists in a clearer recognition of the relationships between different groups of fishes, together with a more precise indication of their lines of descent; and it contains also critical observations on various disputed points, such as the origin of paired fins, development of dental plates and dermal armor from shagreen-like scales, atrophy of the lower jaw and shoulder-girdle, modification of the caudal fin, and similar issues. And in conclusion it is stated that "the paleontology of fishes is not less emphatic in the support of the doctrine of descent than that of any other division of the animal kingdom"; also that "we do not and cannot know the oldest fishes, as they would not have had hard parts for preservation, but we may hope to come to know many more old ones, and older ones still, than we do at present."

The author devotes special consideration to those ancient forms whose structure he has so ably elucidated in earlier memoirs. As for the ostracoderms, a most enigmatical group, which he at one time supposed were derived from the primitive elasmobranch stem (owing to the resemblance of Thelodus scales to shagreen), an independent origin is now admitted to be possible; but the idea is discredited that they had any share in the evolution of more recent types of fishes. The Cœlolepidæ, to which "Cephalaspis as well as Pteraspis and its allies are traceable," were certainly shark-like

[1] Marsh, O. C. Introduction and Succession of Vertebrate Life in America. *Proc. Amer. Assoc. Adv. Sci.*, Nashville Meeting, 1873.

Osborn, H. F. The Rise of the Mammalia in North America, *ibid.*, Madison Meeting, 1893.

creatures, even if they were not offshoots from some primitive form of shark.

A novel and somewhat surprising interpretation of the equally problematical arthrodires is given, to the effect that they are teleostomes belonging to the order Actinopterygii. Newberry, it is true, imagined a resemblance to exist between Macropetalichthys and recent sturgeons; but we know now that this genus has nothing to do with coccosteans, and Newberry totally misapprehended its structure. The lack of a shoulder-girdle and lower jaw (properly speaking) in all coccosteans, — an anomaly which they share in common with ostracoderms, — and the peculiar arrangement and mode of growth of the dermal plates, are characters which, to our mind at least, are irreconcilable with actinopterygian affinities. Although functional "mandibles" and "maxillaries" are often present, yet they are evidently only modified dermal plates of the same nature as the body armoring; and the former are suspended in soft tissues without any articulation with the cranium or other bones whatsoever. They are no more homologous with the jaws of bony fishes than is the so-called "clavicular" with a pectoral arch. Bashford Dean would exclude arthrodires from fishes altogether, as Cope did the ostracoderms; and elsewhere a tendency may be noticed looking toward the revival of M'Coy's Placodermata.

Turning to the elasmobranchs, Dr. Traquair again surprises us by declaring that their paleontological history does not throw any definite light on the disputed origin of paired limbs or "on the question whether the so-called archipterygium is the primary form of paired fin in the fish, or only a secondary modification." Nevertheless, he cautiously admits that "the paired fins of the Upper Devonian shark, Cladoselache, as described by Bashford Dean, Smith Woodward, and others, seem to favor the lateral fold theory." Next follows a very interesting and very learned discussion of the Crossopterygii, the Dipnoi, and Actinopterygii, into which, however, space forbids us to enter. His conclusions regarding the first two groups are that "the Crossopterygii were not derived *from* the Dipnoi, and that the modern representatives of the latter group are degenerate forms; yet as to the immediate ancestry of the Dipnoi themselves and the diphyletic origin of the so-called archipterygium, we had best for the present keep an open mind." It need scarcely be added that this lucid and timely essay of Dr. Traquair's is of prime importance, not only to palæontologists, but to zoologists everywhere.

C. R. E.

Triassic Fossils from Eastern Siberia.[1] — In this publication, Dr. A. Bittner has described the fragments of a pelecypod and beachiopod fauna from the Lower Trias of the Ussuri region, near Vladivostock, in eastern Siberia. Although the fauna is not rich, it is especially interesting, coming from the same formation from which Dr. C. Diener[2] has already described the characteristic cephalopod fauna.

While most of the species are new, it is surprising to find among them forms either identical or closely related to European forms, among which may be mentioned *Pecten conf. alberti* Goldfuss, *Pseudomonotis multiformis* Bittner, and *Myophoria conf. lævigata* Alberti, of which representative forms, or geographic variations, are found in the Werfen beds of the Tyrol.

Diener, on the other hand, found the cephalopod fauna of the Ussuri region absolutely different from that of the Tyrol, with its nearest relationships rather with the Triassic faunas of northern Siberia and India. It is, therefore, remarkable that a kinship with the European Trias should show itself in the pelecypod fauna, which also shows decided affinities with some forms in the Lower Triassic Meekoceras beds of southeastern Idaho, near Soda Springs. The cephalopod fauna of the Ussuri region is almost identical with that collected, but not yet described, by Professor A. Hyatt and the writer from Wood's Cañon near Soda Springs. These additional species will aid greatly in the correlation of the Idaho beds with those of the Ussuri region, and incidentally with the Mediterranean Trias.

J. P. S.

The Upper Paleozoic Fauna of Russia.[3] — In this paper N. Jakolew has added another link to the chain that connects the Upper Carboniferous faunas of Russia with those of America. Up to the present our knowledge of the gastropods of the Permo-Carboniferous, or Artinsk, beds of Russia has been scanty, but in this work we find a number of American species in the beds that lie above the Uralian and below the true Permian beds, analogous to the uppermost Missourian and possibly the lower part of the Wichita formation of the Mississippi valley region. The analogies between these transitional formations on the two continents have long been recognized,

[1] Bittner, A. Versteinerungen aus den Trias-Ablagerungen des Süd-Ussuri-Gebietes in der ostsibirischen Küstenprovinz, *Mém. Comité Géol. Russie*, vol. vii, No. 4, 1899.

[2] *Mém. Comité Géol. Russie*, vol. xiv, No. 3, 1895.

[3] Jakolew, N. Die Fauna einiger oberpalaeozoischer Ablagerungen Russlands. I, Die Cephalopoden und Gastropoden, *Mém. Comité Géol. Russie*, vol. xv, No. 3, 1899.

but every bit of additional evidence is welcomed. It all tends to show that in the time of the uppermost Coal Measures the great western ocean had extensions as far as the Mississippi valley on the one side, and to eastern Russia on the other, since the brachiopod, gastropod, and cephalopod faunas of the two regions have many species in common. Dr. Jakolew also announces the publication, in the near future, by Professor Tschernyschew, of an extensive work on the brachiopod faunas of the Upper Carboniferous of the Ural region, in which correlations will be made with the American formations and faunas.

J. P. S.

QUARTERLY RECORD OF GIFTS, APPOINTMENTS, RETIREMENTS, AND DEATHS.

EDUCATIONAL GIFTS.

American Museum of Natural History, $25,000, by the will of Oswald Ottendorfer ; $5000, by the will of Henry Villard.

Amherst College, $75,000, from D. Willis James and C. M. Platt ; $25,000, from other sources.

Augustana College (Illinois), $30,000, from E. C. and J. A. Erickssen.

Aurora College (Illinois), $50,000, from Andrew Carnegie.

Baptist Female University of Raleigh, N. C., $20,000, by the will of Chief Justice Faircloth.

Bates College, $10,000, by the will of Joseph Ricker.

Beloit College, a conditional gift of $200,000, from Dr. D. K. Pearson.

Bowdoin College, $20,000, by the will of Joseph Ricker.

Brown University, $250,000, from John D. Rockefeller, on condition that the endowment be increased to $2,000,000 ; $30,000, from two anonymous givers.

Carleton College, $50,000, from Dr. D. K. Pearson ; $100,000, from other sources.

Carson and Newman College (Tennessee), a conditional gift of $15,000, from John D. Rockefeller.

Castine, Maine, $100,000, by the will of Charles F. Emerson, for a public library.

Chicago University, $1,500,000, from John D. Rockefeller ; $25,000, from Leon Mandell.

Colorado College, $50,000, towards the completion of the scientific building.

Cooper Union (New York), $20,000, by the will of Oswald Ottendorfer.

Harvard University, $20,000, by the will of the late Governor Roger Wolcott ; $50,000, by the will of Henry Villard.

Johns Hopkins University, real estate valued at $750,000, from William Wyman and Francis W. Jenks, upon condition that $1,000,000 be collected for the University. We understand that nearly the whole amount has been subscribed.

Lehigh University, $5000, from Warren A. Wilbur.

Malden (Mass.) Public Library, $125,000, from Elisha H. Converse.

New York Free Circulating Library, $20,000, by the will of Oswald Ottendorfer.

Northwestern University, $30,000, from Dr. D. K. Pearson.

Oberlin College, a conditional gift of $200,000, from John D. Rockefeller.

Rutgers College, $25,000, by the will of J. A. Vanderpool.

Syracuse Public Library, $200,000, from Andrew Carnegie.

Syracuse University, a conditional gift of $400,000, from John D. Archbold.

The University of Buffalo, $50,000, for the erection of the Gratwick Research Laboratory.

University of Pennsylvania, funds yielding $400, for a prize in the school of biology, from an anonymous friend.

University of Wisconsin, $1000, from Charles F. Pfister; $1000, from Fred Vogel.

Upper Iowa University, $225,000, from Andrew Carnegie.

Washington and Jefferson College, $60,000, from W. J. Thompson, for library building and equipment.

Wellesley College, $25,000, from H. H. Hunnewell, for the botanical department.

Wesleyan University, $2000, from G. W. Quereau, for the library; $1000, from C. H. Buck.

Yale University, $50,000, by the will of Albert E. Kent of Chicago; $80,000, by the death of B. D. Silliman; a conditional gift of $500,000, by the will of T. B. Winthrop; $68,152, from the estate of the late John De Koven; a part of the estate of the late Professor E. E. Salisbury, estimated at $150,000; $30,000, from Alfred Vanderbilt; $50,000, by the will of Henry Villard.

APPOINTMENTS.

Mr. Outram Bangs, assistant in mammalogy in the Museum of Comparative Zoölogy at Cambridge, Mass. — Professor Franz Boas, curator of ethnology in the American Museum of Natural History. — Dr. H. Boruttau, professor of physiology in the University at Göttingen. — Professor H. C. Bumpus, curator of invertebrate zoölogy and assistant to the president in the American Museum of Natural History, New York city. — Dr. A. Burian, docent for physiology in the University at Leipzig. — Mr. E. J. Butler, official botanist to the Indian government. — F. M. Chapman, assistant curator of mammals and birds in the American Museum of Natural History. — Dr. F. Czapek, docent for anatomy and physiology of plants in the German University at Prag. — Dr. Paul Eisler, professor extraordinary of anatomy in the University at Leipzig. — Dr. M. Fürbringer of Jena, professor of anatomy in the University at Heidelberg, as successor to Gegenbaur. — Myron L. Fuller, assistant geologist on the United States Geological Survey. — Joaquin Gonzalez Hidalgo, director of the Natural History Museum at Madrid. — Dr. Grabowski of Braunschweig, director of the zoölogical gardens at Breslau. — Dr. L. P. Gratacap, curator of mineralogy in the American Museum of Natural History. — Dr. Valentin Häcker of Freiburg i. B., professor of zoölogy in the Stuttgart Technical School. —

Miss Clara Hamburger, assistant in the zoölogical institute of the University at Breslau. — Mr. G. T. Hastings of Cornell, teacher of science in the English Institute at Santiago, Chile. — Dr. Erich Kaiser of Bonn, geologist of the Prussian geological survey in Berlin. — Dr. Friedrich Klein, professor extraordinary of physiology in the University at Kiel. — A. G. Leonard of the University of Missouri, professor of mining and mineralogy in the University of Idaho, at Moscow, Idaho. — Dr. G. S. Lingle, professor of experimental physiology in Rush Medical College. — Dr. Rudolf Martin, professor of physical anthropology in the University at Zürich. — Dr. Anton Nestler, professor extraordinary of botany in the German University at Prag. — Dr. F. Reinke, professor extraordinary of anatomy in the University at Rostock. — Dr. Arthur Robinson, professor of anatomy in King's College, London. — Dr. A. Sauer of Heidelberg, director of the geological survey at Stuttgart. — Dr. Marshall H. Saville, curator of Mexican and Central American archæology in the American Museum of Natural History. — Dr. F. Schenck of Würzburg, professor of physiology in the University at Marburg. — O. Schneider, geologist of the Prussian geological survey. — Dr. Oscar Schulz, privat docent for physiology in the University at Erlangen. — Dr. H. Stechmann, director of the Breslau zoölogical gardens. — Dr. L. Steigert, geologist of the Prussian geological survey. — Dr. Alexander Steuer, docent for geology and paleontology in the Darmstadt technical school. — Dr. H. Stille, geologist of the Prussian geological survey. — Dr. Fr. K. Studnička, docent for zoölogical histology in the Bohemian University at Prag. — Arthur Thompson of Oxford, professor of anatomy in the Royal Academy, London. — Dr. O. Tietze, geologist of the Prussian geological survey. — Dr. A. Tschermak, assistant in the physiological laboratory of the University at Leipzig. — Professor G. Vasseur, conservator of geology in the Museum of Natural History at Marseilles. — Professor A. Vayssiere, conservator of zoölogy in the Museum of Natural History at Marseilles. — Dr. Max Verworn, professor extraordinary of physiology and director of the physiological institute at the University at Göttingen. — Dr. A. Voelzmann, professor extraordinary of zoölogy in the University at Berlin. — Dr. Vogel of Hamburg, bacteriologist in the agricultural experiment station in Posen. — Dr. Charles H. Warren, instructor in mineralogy and geology in the Massachusetts Institute of Technology. — Dr. G. Wetzel, docent for anatomy in the University at Berlin. — Dr. E. Woloszczak, professor of botany in the technical school at Lemburg, Austria. — Dr. Fred. C. Zapffe, professor of histology in the medical school of the University of Illinois. — Dr. Theodor Ziehen of Jena, professor of psychology in the University at Utrecht. — Dr. W. D. Zoethout, laboratory professor of neurology in Rush Medical College.

RETIRED.

Sir A. Geikie, from the directorship of the geological survey of Great Britain. — Dr. Friedrich Goltz, professor of physiology in the University of Strassburg. —Dr. Georg Meissner, professor of physiology in the University at Göttingen. — Dr. E. von Mozsisovics of Vienna, from the position of vice-director of the Austrian geological survey. — Dr. Max Reess, professor of botany in the University at Erlangen. — John C. Smock, for ten years state geologist of New Jersey. — Dr. Filippo Sylvestri, from the position of chief of the zoölogical section of the National Museum of Buenos Aires.

DEATHS.

Dr. Theodor Adensamer, zoölogist, in Baden, near Vienna, November 16, aged 33. — Dr. W. von Ahles, emeritus professor of botany in the Stuttgart technical school, in August. — Dr. Richard Altmann, professor extraordinary of histology in the University of Leipzig. — F. R. Bedford, student of echinoderms, in London. — Dr. G. Boerlage, assistant director of the botanical gardens at Buitenzorg, Java, in September, while on an expedition to Ternate. — Dr. Breusing, assistant in geology in the Hannover technical school, while on a trip in Dutch Guiana. — Mr. Philip Crowley, entomologist and ornithologist, in London, December 20. — S. W. Egan, of the geological survey of Ireland, at Dublin, January 6. — Dr. Gustav Hartlaub, the celebrated ornithologist, at Bremen, November 20, aged 87. — Dr. R. Hegeler, privat docent for botany at Rostock, at Stuttgart, September 28. — Dr. George Duryea Hulst, the well-known entomologist, in Brooklyn, N. Y., November 5, aged 54. — Dr. William King, for thirteen years connected with the geological survey of India. — Dr. Philip H. Kirsch, ichthyologist, at Las Cruces, New Mexico. — Dr. S. J. Korschinski, botanist, at St. Petersburg, December 1. — Mr. R. D. Lacoe, the well-known collector of carboniferous fossils, at West Pittston, Pa., February 5. — John Henry Leech, entomologist, at Salisbury, England, December 29, aged 38. — Thomas Benton Marbut, geologist and mining engineer, at Esther, Mo., September 16, aged 29. — Dr. W. von der Marck, geologist, in Hamm, Germany, November 22, aged 86. — Dr. Paul Marès, botanist, May 21, 1900, at Mustapha, near Algiers. — Charles Marquet, entomologist of the Museum of Natural History at Toulouse. — John Potter Marshall, emeritus professor of geology and mineralogy in Tufts College, February 4, aged 76. Professor Max von Pettenkoffer of the University at Munich, by suicide, in January, aged 83. — Professor Dr. Adolf Pichler, geologist of the Tyrol, at Innsbruck, November 15, aged 82. — E. Roze, botanist, at Chatou, France, May 25, 1900. — Michael Edward, Baron de Selys-Longchamps, entomologist, well known for his studies of the Odonata, at Liège, Belgium, December 11, aged 86. — Dr. Otto Staudinger of Dresden, an eminent student of

Lepidoptera, at Luzern, October 13, aged 70. — Dr. Hermann Stechmanns, director of the Breslau Zoölogical Gardens. — Dr. Otto Martin Torell, director of the Geological Institute in Lund, Sweden. — Thomas A. Williams, botanist, connected with the United States Department of Agriculture, and formerly a student of Aphides, at Washington, D. C., December 23, aged 35. — Dr. Friedrich Anton Zürn, a well-known investigator of animal parasites, September 11, aged 65.

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IN THEIR WIDEST SENSE

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THE

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TWO NEW MYRMECOPHILOUS GENERA OF ABERRANT PHORIDÆ FROM TEXAS.[1]

CHARLES THOMAS BRUES.

THE discovery of two new genera of myrmecophilous diptera allied to the Stethopathidæ, in Texas, is entirely unexpected. That a family of wingless Diptera hitherto represented by a small group of genera in the Old World should suddenly appear in North America is, to say the least, a very unusual occurrence.

The new genera are also very interesting from a taxonomic point of view, as they show very clearly the affinities of the Stethopathidæ and Phoridæ, which have hitherto appeared somewhat doubtful.

Last October, while collecting ants in one of the pecan groves upon the outskirts of Austin, Texas, Dr. Wheeler of the University of Texas found in a nest of *Solenopsis geminata* Fabr. several specimens of a peculiar dipteron with rudimentary wings. Upon closer examination they seemed to be Phoridæ, although their habitus was extremely like that of the Stethopathidæ, from which they were easily distinguished by their halteres and small wings.

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, No. 15.

About a month later Dr. Wheeler called my attention to a number of somewhat similar flies in a nest of *Eciton cœcum* Latr. which had been in the laboratory for some time. These also proved to be Phoridæ, but of a still more degenerate type.

A more careful examination has shown that these two genera are referable to the Stethopathidæ, but at the same time are evidently degenerate Phoridæ, so that the former family must be included in the Phoridæ. Such an addition does not make the family an incongruous one. When Loew ('57) placed his African Psyllomyia in the Phoridæ he made a statement equally applicable to the present addition:

"Wenn irgend etwas geeignet ist über die verwandtschaftlichen Beziehungen der Phoriden eine Aufklärung zu geben, so sind diess Arten, welche so sehr von dem Typus der in der alten Gattung *Phora* vereinigten abweichen, wie die oben beschriebene, und welche doch der Familie der Phoriden mit so bestimmt ausgesprochener Entschiedenheit angehören wie sie.

"Leider muss ich bekennen, dass die oft wiederholte Vergleichung der *Psyllomyia testacea* mit Diptern gar verschiedener Familien mir nach dieser Richtung hin durchaus kein positives Resultat gegeben hat, so dass ich die Familie der Phoriden von allen andern Familien der Diptern noch so scharf getrennt und so unvermittelt zwischen ihnen stehen sehe, wie zuvor."

With the discovery of the still more degenerate forms his remarks lose none of their pertinence.

The family Stethopathidæ was established by Wandolleck in 1898 ('98b) for the reception of several genera of Diptera which are remarkable for the total absence of wings and halteres, besides other less striking peculiarities. Two of the genera which he describes had been previously described by Dahl ('97) as sexes of a single species which he named *Puliciphora lucifera* and placed among the Phoridæ. He, however, considered at the same time that they were a connecting form between the Aphaniptera and Diptera and accordingly announced that he had solved the much-vexed question of the relation of the fleas with the Diptera.

Wandolleck later showed ('98a) that this idea is wholly erroneous as far as the Aphaniptera are concerned, and that

they are in no way related to them, nor, on the other hand, did he consider them to be Phoridæ.

His third genus, which he leaves without a name, had been previously named in his honor by Cook ('98).

The most important characters of the Stethopathidæ, as defined by Wandolleck, are the total absence of wings and halteres, the strongly reduced thorax, very small eyes, large coxæ, and small external genital organs of the female.[1]

Recently Wasmann has described a genus of termitophilous Diptera ('00a) which agrees with the Stethopathidæ in all essentials, except that they possess rudimentary wing-like appendages and a slightly larger thorax. These are characters that would not warrant the erection of another family for their reception. Moreover, the presence of rudimentary thoracic appendages places them still closer to the Phoridæ.

The two Texan genera approach the true Phoridæ even more closely, since one of them possesses both halteres and rudimentary wings, and both have the large macrochætæ of the body hairy, a character which Wasmann has pointed out as distinguishing the Stethopathidæ and Phoridæ. In both of these forms the abdomen is almost completely membranous. The African genus Psyllomia, however, has an abdomen of the true phorid type, while it agrees with one of the new genera, Commoptera, in having rudimentary wings, as well as in the structure of the head. The external sexual organs of the female are so clearly of the phorid type that they present no important deviation.

Through these forms we can pass without any great gaps from the Stethopathidæ to the Phoridæ, and as such is the case, *the family Stethopathidæ is certainly untenable, and the genera hitherto placed there, together with Psyllomyia and the*

[1] I have not considered the form of the mouth-parts in Wandolleck's three genera, which he believes to be entirely different from those of the Phoridæ and all other Diptera. He himself says, however, that Dahl, who has spent much time in studying the Phoridæ, considers them as phorid mouth-parts. He says: "Ich zeigte die Zeichnungen Dahl, der sich seit Jahren mit Phoriden beschaftigt, er erkannte sie sofort als Phoridenmundtheile an. . . ." I think Wandolleck must have exaggerated the extent and importance of the variation in the mouth-parts, for the two Texan genera have typical phorid mouth-parts, often, however, shrunken and distorted in alcoholic specimens.

two described below, had best be considered as the subfamily Stethopathinæ of the Phoridæ.

It does not seem probable that the forms have had a common origin however; even their distribution would preclude this in the case of such a recent group. On the other hand, there seem to be several independent lines of descent which we can to some extent suggest. In Psyllomyia the degeneration consists in the reduction of the eyes, absence of ocelli, and reduction of wings. In Commoptera the eyes are larger, the ocelli present; but the abdomen is extremely degenerate in structure, being almost wholly membranous. Ecitomyia could be more easily derived from forms like Commoptera, as it has very rudimentary wings, no halteres, smaller eyes, smaller thorax (without scutellum), and about equally degenerate abdomen. The degeneration has gone furthest in the genera from the Bismarck Archipelago and west Africa. Here the thorax is exceedingly small, the wings and halteres completely lost, the eyes very small, and the abdominal segments more or less membranous. Of these Stethopathus alone has retained distinct ocelli. Wasmann's Termitoxenia has the immensely swollen abdomen so characteristic of all termitophiles, and a greatly modified head. It does not approach closely to any of the other genera.

The following table, showing the order of degeneracy with regard to different structures in the genera of the Stethopathinæ as compared with Phora, will serve to emphasize the great disparity between the genera. *Phora* is placed at the top in each case and the most degenerate genus at the bottom.[1]

WINGS.	EYES AND OCELLI.	ABDOMEN.	THORAX.
Phora	Phora	Phora	Phora
Psyllomyia	Commoptera	Psyllomyia	Commoptera
Commoptera	Termitoxenia	Chonocephalus	Psyllomyia
Ecitomyia	Stethopathus	Stethopathus	Termitoxenia
Termitoxenia	Psyllomyia	Ecitomyia	Ecitomyia
Stethopathus	Wandolleckia	Commoptera	Stethopathus
Wandolleckia	Ecitomyia	Wandolleckia	Wandolleckia
Chonocephalus	Chonocephalus	Termitoxenia	Chonocephalus

[1] Where ocelli or wings are absent I have judged by the size of the eyes and the thorax.

Still more remarkable is Ænigmatias, represented by *Æ. blattoides* Meinert from Denmark, which does not seem to be closely related to the Stethopathinæ, although I have unfortunately not had access to the original description of Meinert ('90). Its habitus is certainly entirely different from that of any of the genera here mentioned. *Platyphora lubbockii* Verrall has been suggested as the possible male of Ænigmatias, but that is very problematical.

Throughout the winter we had been searching in vain for the males of Ecitomyia, which is very common in the nests of *Eciton cæcum*, but not until spring (February 3) were we able to obtain them. On that day we obtained two specimens from different nests in which the females were abundant. A glimpse at one of them immediately justified any surmises made as to their phorid character, for the males, although much like the females, possessed fully developed wings with the peculiar phorid venation and large halteres!

Such a remarkable amount of variation in usually stable morphological characters may be best explained by the great tendency of all degenerate structures to vary in an unusually high degree, and by a great power of adaptation in the Phoridæ.

The habits of only four of the genera are known with certainty. They are all myrmecophiles or termitophiles. A fifth, Wandolleckia, lives apparently ectoparasitically upon large west African land snails (*Achatina variegata* Roissy).

Their geographical distribution is extremely peculiar and is a case of remarkable discontinuous distribution not due to the great age of a certain type, for it does not seem possible to regard them as an old group, but rather as several independent and to some extent conveying lines of degeneration. This view is strengthened by the above-mentioned impossibility of showing any interrelation of the genera.

The following dichotomy will serve for the identification of the genera thus far known.

STETHOPATHINÆ.

Wingless or with rudimentary wings, eyes reduced, abdominal plates usually much reduced, coxæ very long, face deeply concave, eggs usually very large and causing an enlargement of the abdomen. Males, as far as positively known, easily correlated with the females, but much like the males of the Phorinæ.

GENERA OF STETHOPATHINÆ (FEMALES).[1]

1. Wings and halteres absent 5
   Either wings or halteres or both present 2
2. Both wings and halteres present, the former abbreviated . . 3
   Either wings or halteres present, never both 4
3. Arista of antenna dorsal, abdomen strongly chitinized throughout, proboscis much longer than height of head, very slender
   Psyllomyia Lw.
   Arista terminal, abdominal segments small, the greater part of the abdomen membranous, proboscis shorter than height of head, stout
   Commoptera *gen. nov.*
4. Abdomen greatly swollen, its apical segments bent forward on the ventral side of abdomen. Wings absent, halteres present
   Termitoxenia Wasmann
   Abdominal segments normal in position, wings present, halteres absent
   Ecitomyia *gen. nov.*
5. Ocelli present . . . . . Stethopathus Wand.
   Ocelli absent 6
6. Head longer than wide, subtriangular, palpi when viewed from above extending far beyond anterior margin of head. Two macrochætæ on posterior margin of head . . . . . Wandolleckia Cook
   Head wider than long, trapezoidal, palpi not extending forward beyond front margin of head . . . . . Chonocephalus Wand.

If we desire to consider Ænigmatias as belonging here, it may be separated from all the other genera by its stout blattid-like form, with the thorax as wide as the abdomen. The problematical male (Platyphora) differs from the male of Ecitomyia in having no macrochætæ on the dorsum of the thorax.

[1] The male of only one genus (Ecitomyia) is known and it may be recognized by the diagnosis given farther on.

Psyllomyia Loew.

Head swollen, lentiform, completely chitinized. Eyes extremely small, somewhat wider than high, situated on the sides of the head. Ocelli absent. Antennæ two-jointed, only of medium size, each situated in a cavity, separated by the front margin of the head, which extends somewhat between them. Arista very thickly clothed with moderately long hairs. Palpi projecting, not very stout, bristly along the lower side and at the tip. Proboscis very long, geniculate, without distinct labellæ. Thorax rounded. Abdomen and legs as in Phora, the latter very bare, only at the tips of the four posterior tibiæ, with short, small bristles. Wings abbreviated, leathery, resting upon the dorsum of the abdomen and having the general appearance of short elytra (about as in Meloë). They have indications of three very thick, rib-like longitudinal veins, which are beset with small black bristles, some of which are noticeable because of their much greater length. Halteres beneath the wings, almost rudimentary.

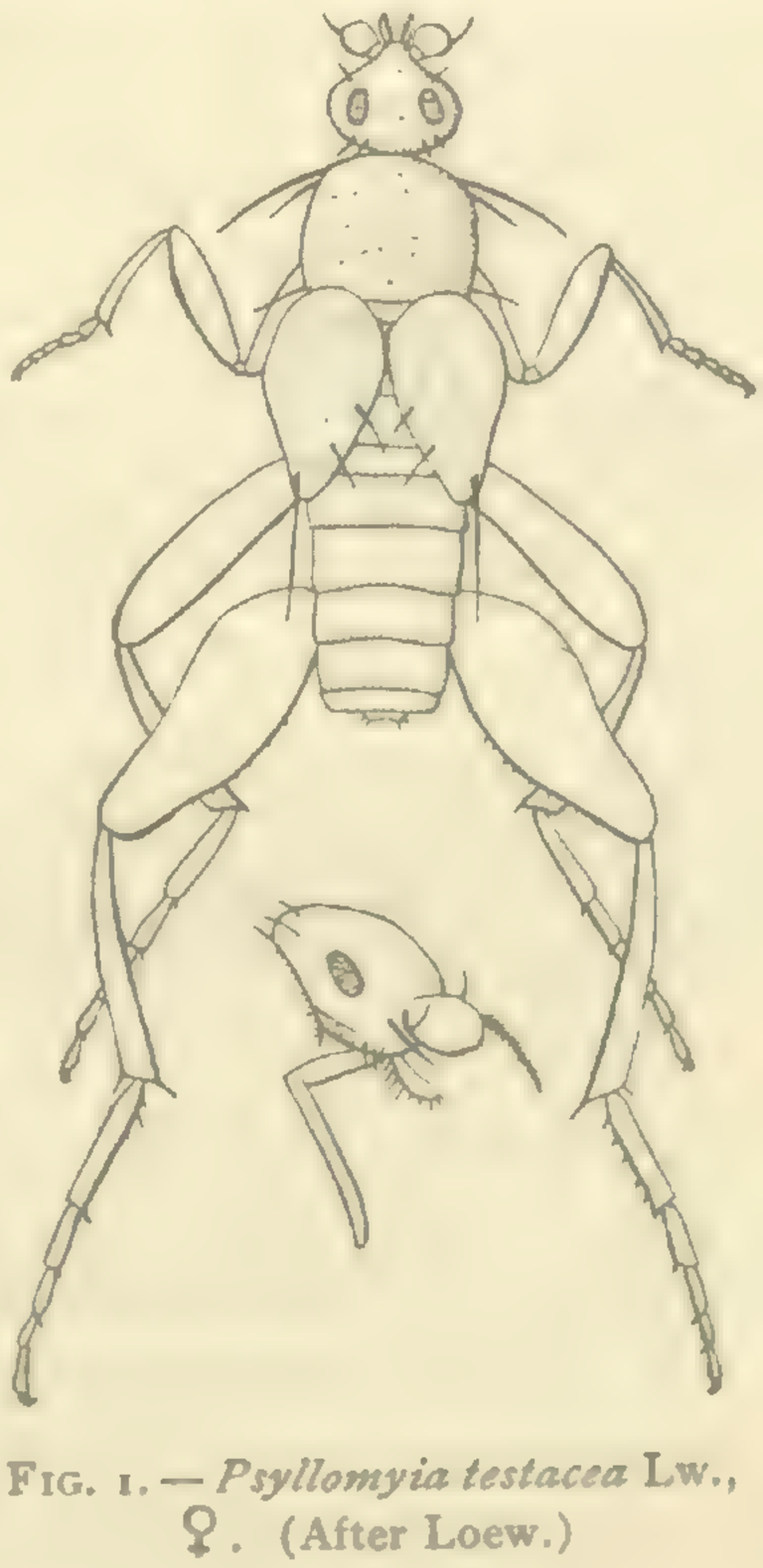

FIG. 1.—*Psyllomyia testacea* Lw., ♀. (After Loew.)

Psyllomyia testacea Lw. (Fig. 1). Length 1.75 mm. Pale brownish yellow. Arista and wings, with the exception of the longitudinal veins, more yellowish white; the entire abdomen black. The entire upper side of the head finely punctured and covered with hardly perceptible hairs; besides these there are two posteriorly directed black macrochætæ on the extreme anterior part of the head, two anteriorly directed ones on each side close to the base of the proboscis, one anteriorly directed one immediately in front of the eye, and four posteriorly directed ones upon the occiput, close to the rather acute margin of the head. Thorax with scattered black bristles, one of especially large size on the side of the thorax at the upper part of the front coxa. On the wings two bristles are especially large, one of them on the inner margin, the other near the apex.

The specimens described by Loew were collected in Kaffir Land, Africa. Of all the genera this most closely resembles the Phorinæ, yet it shows undoubted affinities with Commoptera. The long proboscis is apparently quite different from those of the other genera.[1] The antennæ have a dorsal arista,

[1] Wasmann, however, mentions that Dorniphora Dahl, one of the Phorinæ, possesses a somewhat similar proboscis.

which is evidently homologous to the three apical joints in the antennæ of the other genera.[1] Such a variation in the insertion of the arista is seen also in the Phorinæ. The palpi and eyes are very small. The wings are shaped much as in Commoptera, but are almost free from bristles along the costa. The legs are of the usual phorid type, and judging from the figure the coxæ must be exceedingly lengthened.

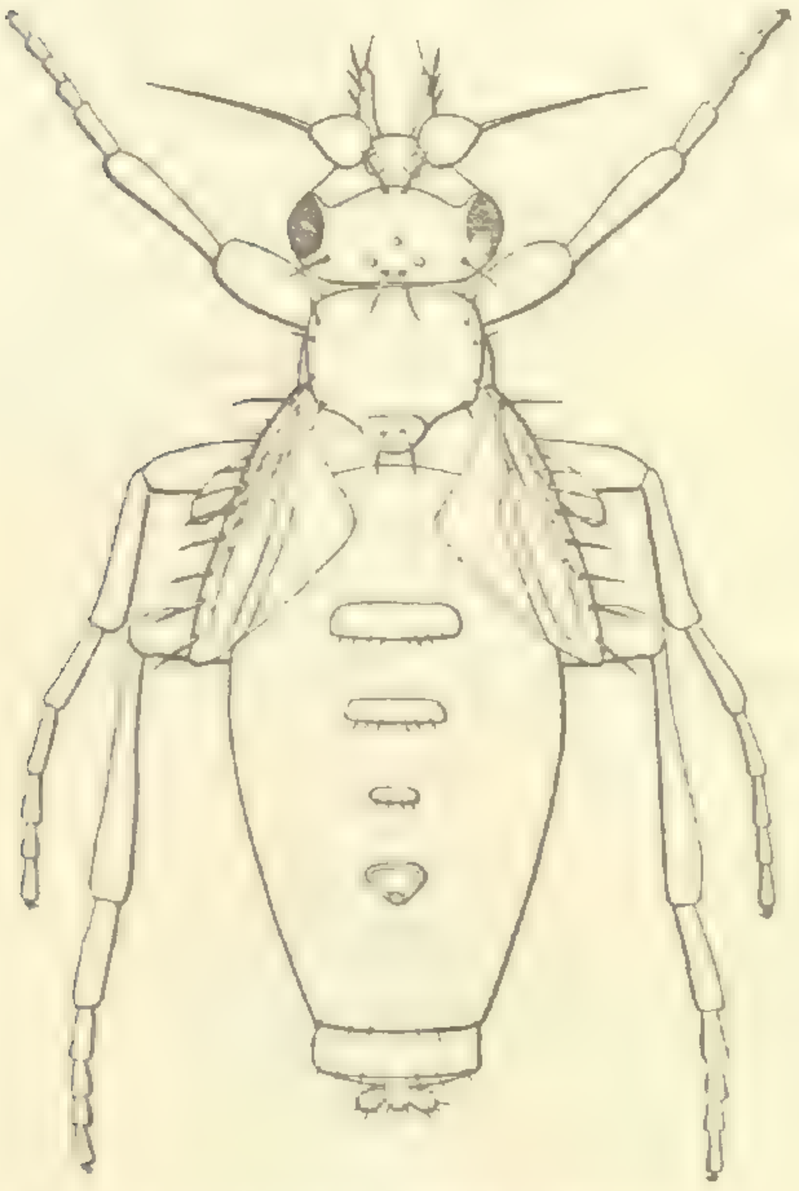

FIG. 2. — *Commoptera solenopsidis*, n. sp. Female, dorsal view.

Nothing whatever was known by Loew of the habits of this peculiar form, but Wasmann has mentioned it ('00b) as the guest of a south African doryline ant (*Dorylus helvolus* Linn.). He also includes in his list of the guests of the South-American *Eciton predator* "Phorid *N.G. n. sp.* (prope *P. testacea* Lw.), *S. Catharina*."

COMMOPTERA SOLENOPSIDIS (*gen. et sp. nov.*).

Female (Figs. 2 and 3). Length 1.5 mm. Abdomen 1.01 mm. Thorax .26 mm. Head .45 mm. Halteres .19 mm. Pale yellow, head somewhat darker, and abdomen somewhat lighter, legs concolorous with thorax. Body everywhere more or less covered with fine hairs. Head, seen from the side, oval. Vertex gently descending, about two-thirds as long as the mesonotum; face as long as the mesonotum, the antennæ inserted low down close to the mouth, in elongate vertical depressions which are quite shallow. Antennæ of the usual form, arista terminal, strongly pubescent. Eyes oval, one-half as high as the head and two-thirds as wide as high, with the ommatidia separated and convex. They are

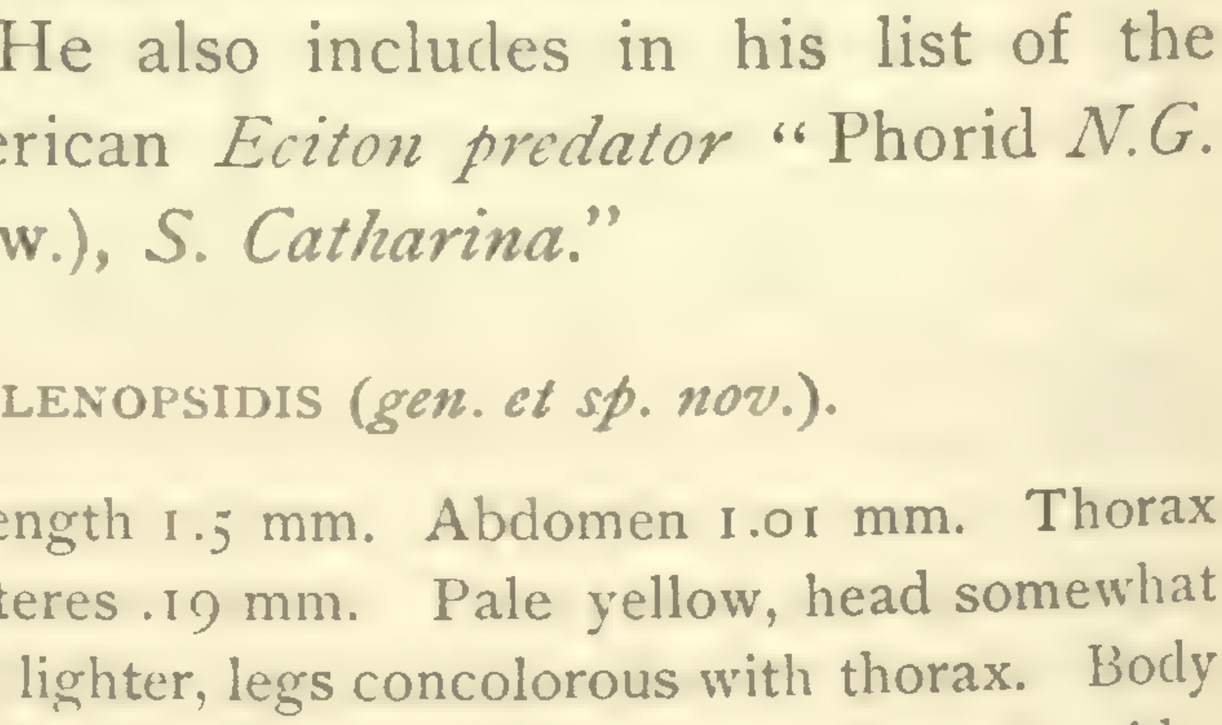

FIG. 3. — *Commoptera solenopsidis*, n. sp. Female, side view.

[1] Wandolleck speaks of them as antennal joints, but such a nomenclature seems inconsistent with the one usually adopted.

placed slightly above the middle of the head. Ocelli large and well developed, occupying their usual position in a triangle upon the vertex. Palpi as long as eye, small and slender, with the usual macrochætæ which are also smaller. Proboscis two-thirds as long as head, stout and thick (Fig. 4). Cheeks each with a large, downwardly directed macrochæta. A pair of closely approximated, anteriorly directed bristles on anterior margin of front; another posteriorly directed pair on the posterior margin of the head; and a third outwardly directed pair near the posterio-lateral corners of the head. Mesonotum somewhat wider than long, with four outwardly directed marginal macrochætæ on each side. Scutellum small, convex, much rounded behind, less so in front, projecting somewhat over the metathorax behind, with a pair of strong approximated median macrochætæ. Posterior part of metathorax produced back into the abdomen like a very large scutellum. Seen from the side the thorax is oval, not much larger than the head. The anterior coxæ are exceedingly large and freely movable. The other coxæ smaller, more or less connate with the thorax, the hind pair extending back beneath the base of the abdomen. Prothoracic stigma large and distinct. Wings short, less than one-third as long as the body, rather narrow and pointed, subtriangular in outline (Fig. 5). Along the costa are two rows of stout macrochætæ; elsewhere the wings are covered with fine. short hairs. Veins not sharply distinguishable from the surrounding membrane, consisting of two longitudinal veins which coalesce at the tip of the wing. Toward the base of the wing the first furcates, as does also the second. The anterior branch of the second vein unites with the posterior branch of the first. Posterior branch of second vein evanescent. Two vestigial posterior veins are present also. Halteres immediately behind the wings large, consisting of three distinct joints, the basal two small, quadrate; the third, large, stout, oval (Fig. 5). The third joint is almost as large as the palpi and flattened behind, so that a sharp edge separates the plane part from the remainder of the joint. Abdomen elongate oval, somewhat depressed, finely hairy, membranous except for the small dorsal plates, which are extremely rudimental. The first is a wide band, extending only one-third

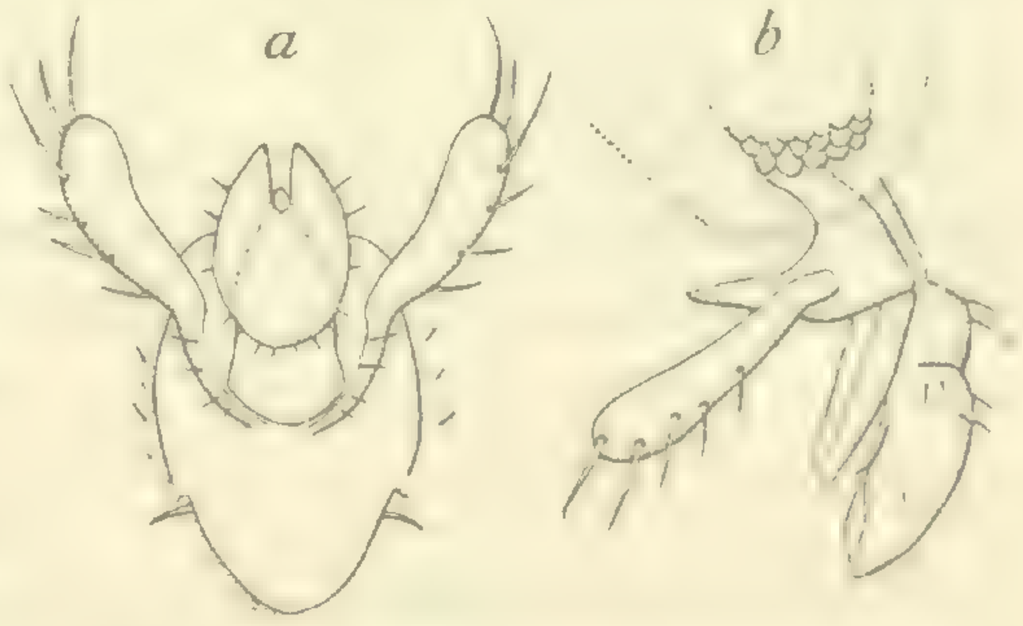

FIG. 4.—Mouth-parts of *Commoptera solenopsidis*, n. sp. *a*, ventral view; *b*, lateral view.

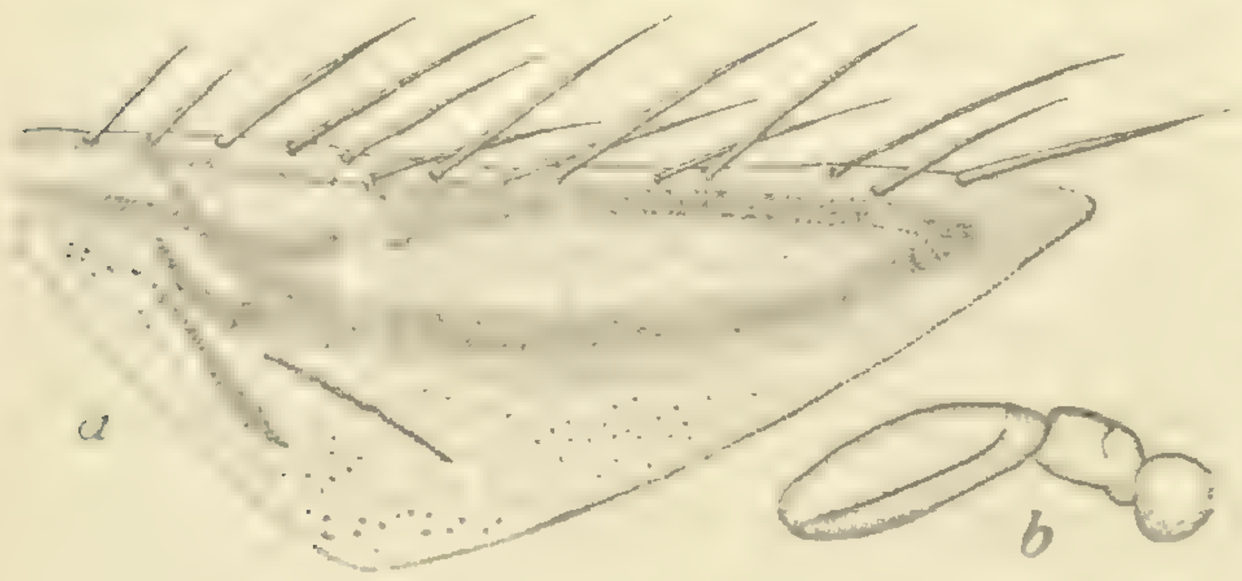

FIG. 5.—*Commoptera solenopsidis*, n. sp. *a*, wing; *b*, halter.

across the abdomen; the second, four times as wide as long, oval; the third, similar and much smaller; fourth, triangular, with a large pit in the center. Sexual organs of the usual form. The central axis is broadly rounded and bisetose at tip; lamellæ short, club-shaped, and rounded at the tips, quite bristly. Last two abdominal segments with rows of marginal bristles. The last two segments of the abdomen are retractile, as in Ecitomyia, and capable of being exserted to a considerable extent. Legs moderately stout. Hind metatarsi flattened, and with regular rows of transverse macrochætæ.

Three female specimens found in a nest of *Solenopsis geminata* Fabr., at Austin, Texas, Oct. 24, 1900, by Dr. Wm. M. Wheeler.

The structure of Commoptera is on the whole more degenerate than that of Psyllomyia. The eyes are larger and the ocelli present, but the swollen membranous abdomen and general habitus are at least a greater departure from the phorid type, if not a mark of degeneracy.

The head and its appendages are much as in the genera described by Wandolleck. The eyes are, however, less reduced and the ocelli nearly of normal size. A most remarkable difference is seen in the proboscis, which is not long as in Psyllomyia. The mouth-parts do not differ to any extent from those of some Phoras which I have examined.

The thorax and its appendages present nothing new, except the peculiar condition of the wings. At first I thought it possible that the wings were normally of the usual size and had been bitten off around the edges. But this view is disproved by two facts. In the first place, the wings are symmetrical and have the edges perfectly continuous. In only two wings (out of six) did there seem to be any irregular or notched places along the posterior margin. Secondly, the extreme activity of the flies would make it impossible for the Solenopsis, although it is quite an active ant, to gnaw off the wings so as to present even a semblance of the perfect symmetry exhibited. We are then forced to conclude that such abortion is natural and that the wings have been decreased in size on account of the inconvenience they presented to the fly while moving about in the galleries of the Solenopsis nest. Wings would indeed be a great inconvenience in moving about in the narrow galleries and quite an unnecessary burden, when the legs are adapted to such wonderfully quick motions.

The condition of the abdomen is also remarkable. The segments have no doubt been reduced, independently of the secondary swollen condition due to the immense eggs. Such small abdominal plates fitted together in their normal position would form an abdomen so utterly at variance with the size required to perform its natural functions that we must consider the segments reduced and the abdomen also enlarged, probably by post-metamorphic growth. The difference in the size of the abdomen in different specimens of Ecitomyia shows that a considerable post-metamorphic enlargement occurs in that species. The external sexual organs do not depart from those of Phora, except that they may be slightly reduced in size. The fourth abdominal segment differs from all the others in having not a dorsal plate, but a chitinous ring, triangular in shape and surrounding a membranous patch which probably has a glandular function.[1]

There can be no doubt that this peculiar insect is a true myrmecophile, as the nest in which they were found contained numerous individuals, most of which escaped on account of their extreme activity. Although we have examined a great number of similar Solenopsis nests, we have seen no other specimens, so that, in this locality at least, it is much rarer than the genus living with Eciton.[2]

ECITOMYIA WHEELERI *gen. et sp. nov.*

Female (Figs. 6 and 7). Length 1.20 mm. Abdomen .93 mm. Thorax .16 mm. Head .14 mm. Wings .14 mm. Head and thorax yellowish brown, much darkened above. Abdomen yellowish white, its small dorsal plates darker, the first almost piceous. Legs concolorous with the lower portions of the thorax. Head, seen from the side, subtrapezoidal, the front gradually descending, nearly as long as the dorsum of the thorax. Height of antennal cavity about equal to the front, about one-third as deep as high, regularly arcuate. The antennæ (Fig. 8) arising near the base of the cavity, of typical form: first joint small: second, large globose, obtusely pointed at tip; first joint of arista small, distinct; second, longer; third, nearly equal

[1] Owing to the limited number of specimens which we have of this species, I could not examine its structure. It is no doubt similar to the one described at length under Ecitomyia.

[2] Since writing the above, I captured another specimen in a nest of the same ant (April 6th).

to first and second together ; the terminal slender portion not very distinct from the third joint, distinctly plumose. Eyes slightly smaller than second antennal joint, oval, with about twenty facets. Palpi rather slender, arcuate near base, as long as the front, bearing six strong macrochætæ laterally and a few other weaker ones. All of them, especially the larger ones, distinctly and finely hairy.

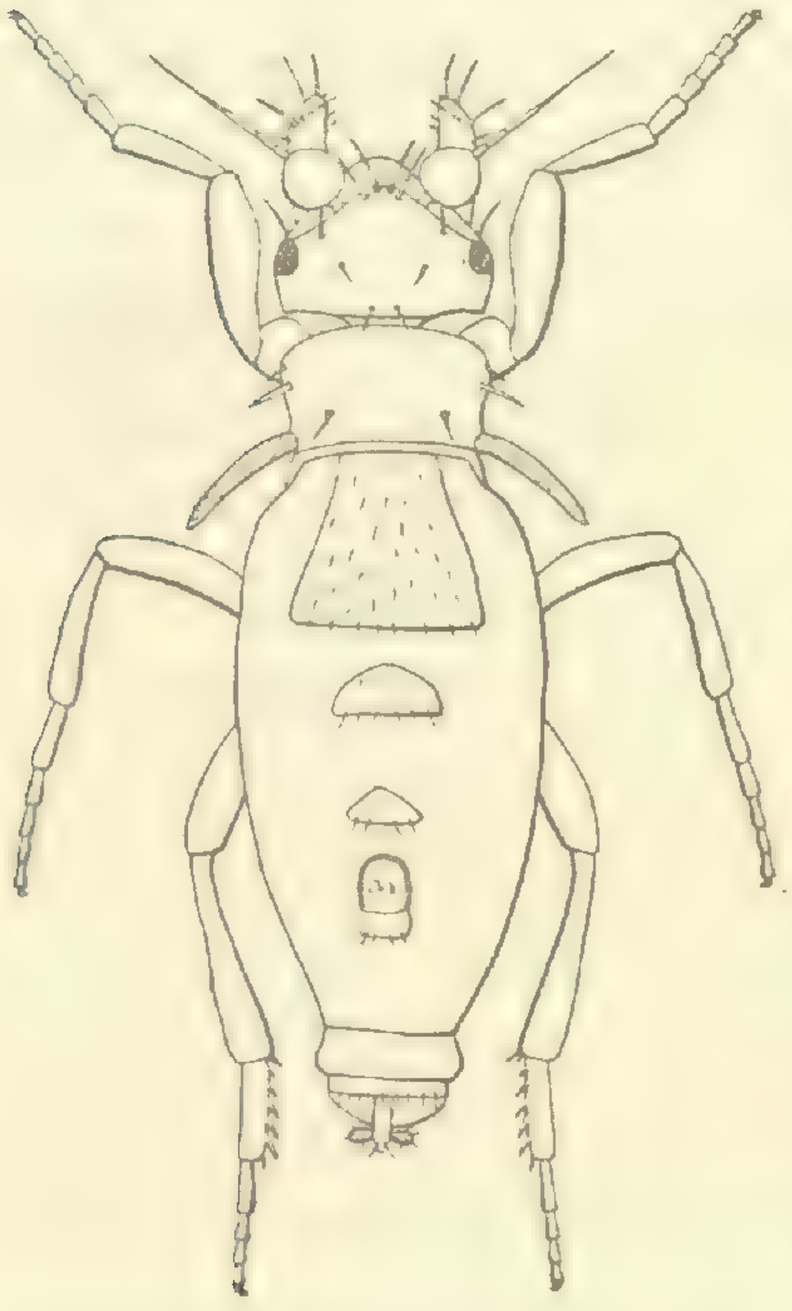

FIG. 6.—*Ecitomyia wheeleri*, n. sp. Female, dorsal view.

Thorax smaller than the head when viewed from the side and longer than high, the suture between the pro- and mesothorax distinct above on the pleuræ, prothoracic stigma distinct (Fig. 9, *d*). Mesopleuræ distinctly hexagonally areolated below. Wings a little longer than the thorax, slender, flat, and obtusely pointed at tip ; covered on the dorsal side with short bristly hairs. Dorsum with six macrochætæ : two small humeral, two larger post-humeral, and two widely separated post-median ones. Metathorax small, concealed to a great extent by the abdomen, which extends over it almost to the meso-metathoracic suture ; viewed from above through the abdominal wall, it appears elongate, subtriangular, and rounded at the apex. Legs rather stout, especially the coxæ and femora. Anterior coxæ two-thirds as long as the femora and freely movable at base ; the four posterior ones more or less connate and not so large. Posterior metatarsi enlarged and flattened, bearing six transverse rows of stout bristles (Fig. 9, *c*). One well-developed spur on posterior tibiæ. Legs everywhere covered with short hairs.

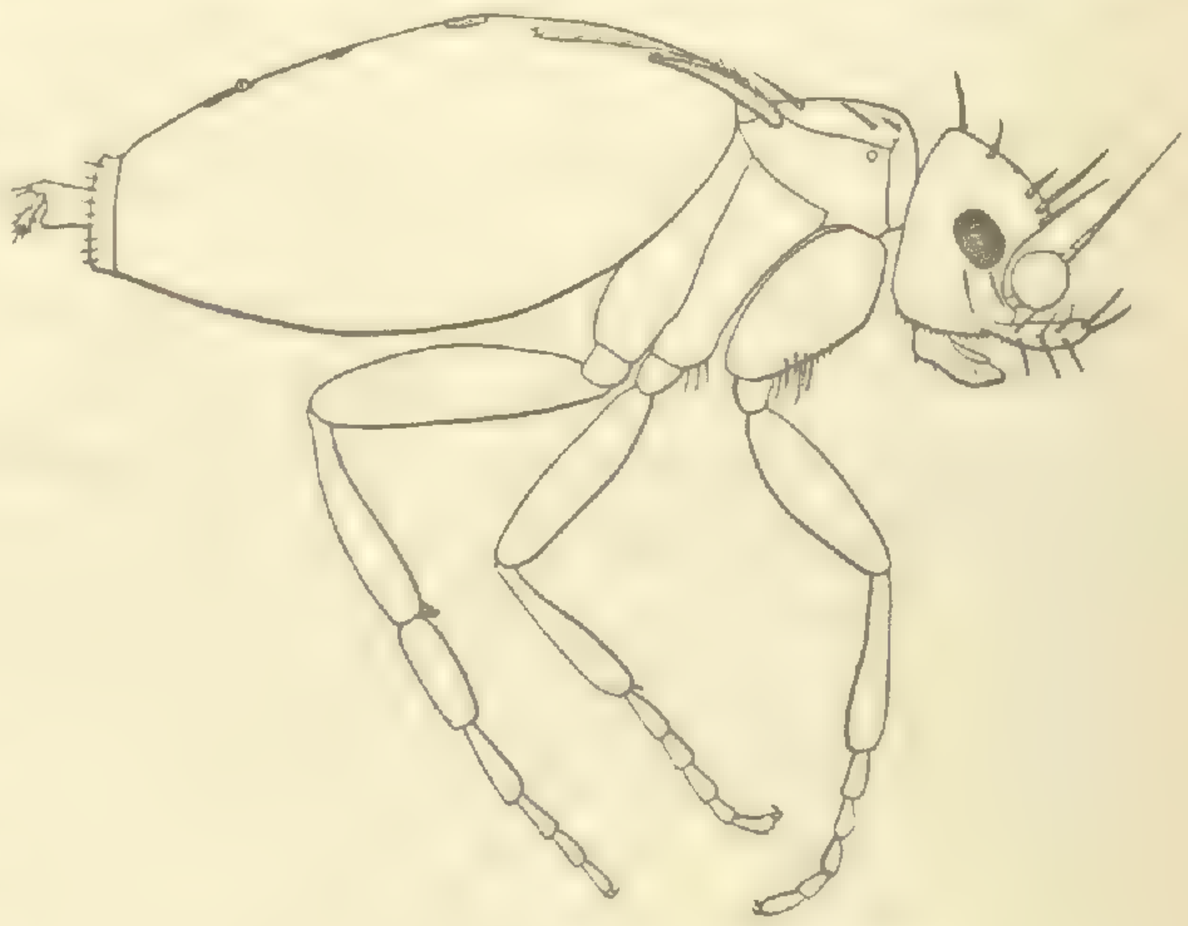

FIG. 7.—*Ecitomyia wheeleri*, n. sp. Female, side view.

Abdomen elongate, oval, acuminate, capable of being exserted at the tip, so that the last three segments may be retracted into the abdomen or pushed out for a distance equal to one-half that of the remainder of the abdomen. When retracted it is about twice as long as the head and thorax taken together. It is almost wholly membranous, only the very small dorsal plates being chitinized. First dorsal plate trapezoidal, as wide as long, and

narrowed basally; second, semicircular; third, subtriangular; fourth, twice as wide as long, rectangular. All except the first are almost rudimental. Just in front of the fourth plate there is a horseshoe-shaped piece of chitin, enclosing a pit from which projects a papilla from the interior of the abdomen (Fig. 9, *e*). Exterior sexual organs consisting of a stout longitudinal axis, obtusely pointed at tip, where it bears two macrochætæ (Fig. 9, *a*). The two lamellæ are attached laterally upon the sides of the central piece near the tip. Lamellæ about as long as the diameter of the central axis, elongate, gradually enlarged toward the tip, where they are rounded; covered with numerous stout bristles. All the apical segments of the abdomen bear several marginal macrochætæ.

FIG. 8.—*Ecitomyia wheeleri*, n. sp. Antenna.

Male (Fig. 10). Length .68 mm.; of wing the same. Body alutaceous. Thorax infuscated above. Abdomen piceous on basal three-fourths above, except on the anterior margins of the segments, where it is much paler. Antennæ, palpi, face, and legs pale testaceous. Anterior tibiæ black, except at extreme base. Hypopygium more or less black. Wings hyaline, veins pale. Head shaped much as in the female; eyes larger, not much smaller than in species of Phora; ocelli present, large, in a triangle on the vertex. Head seen from the side, about twice as high as long. Chætotaxy the same as that of the female, except that the most anterior pair of frontal bristles is shorter. The macrochætæ on the underside of the palpi are also somewhat weaker. Antennæ as in the female. Thorax arched in front, more than twice as long as the head. Scutellum well developed, bearing two strong discal macrochætæ. Dorsum with three marginal macrochætæ and a pair just before the scutellum. Legs longer and more slender than those of the female. Coxæ bristly at tip, hind trochanters each with a pair of very strong recurved spine-like macrochætæ. Wings large, as long as the body, with a stout longitudinal vein which meets the

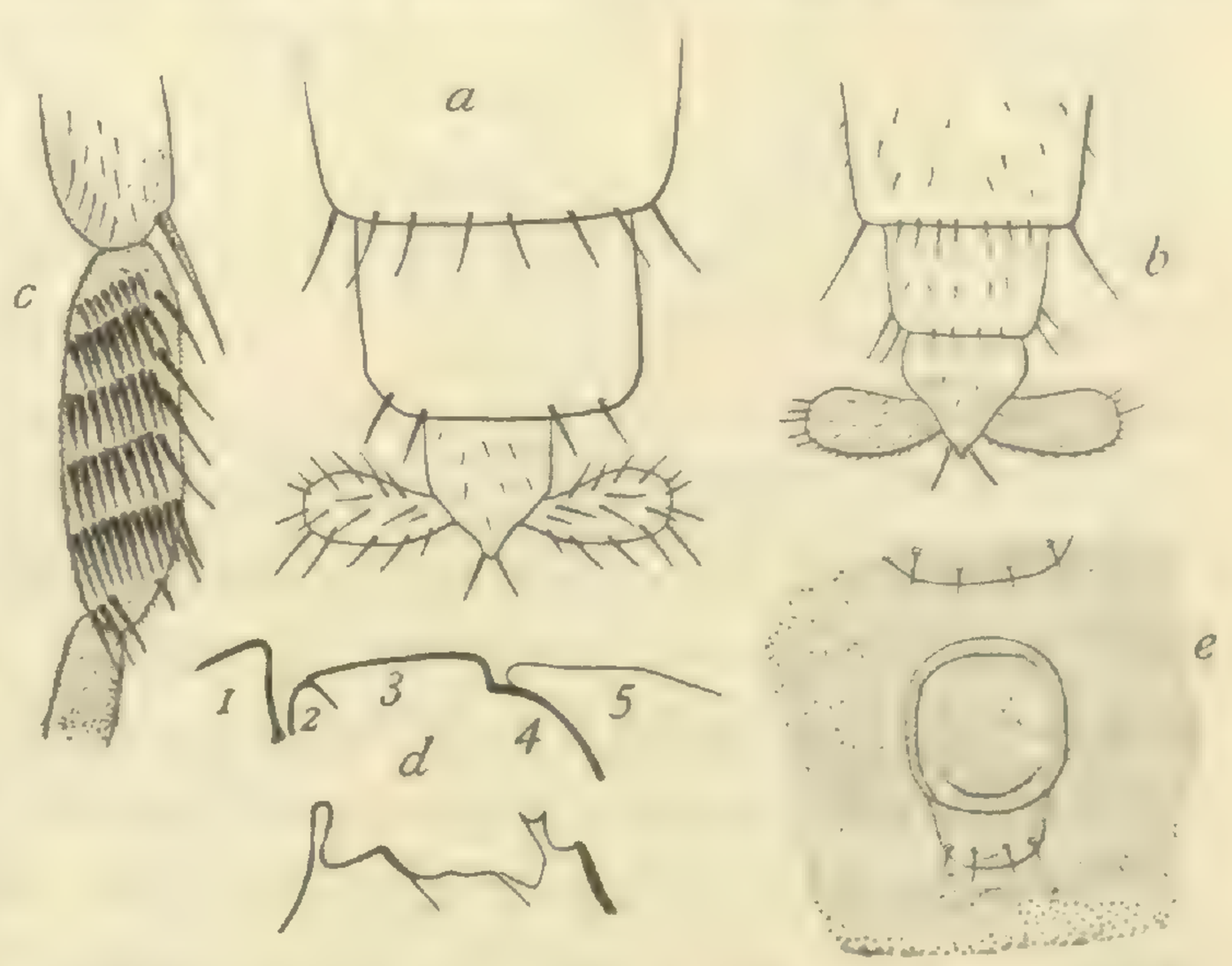

FIG. 9.—*Ecitomyia wheeleri*, n. sp. *a*, apex of abdomen, ♀; *b*, apex of abdomen, Phora sp. (?), ♀; *c*, hind metatarsus, ♀; *d*, diagrammatic median sagittal section of ♀; *1*, head; *2*, prothorax; *3*, mesothorax; *4*, metathorax; *5*, abdomen.

thickened costal margin near the middle of the wing, and three faint, oblique longitudinal veins. Costal vein bristly along its entire length. Halteres about as long as the hind metatarsus, distinctly three-jointed. Abdomen with six segments, the basal ones longest. It is chitinized above and membranous beneath. Hypopygium large, exserted, asymmetrical.

Described from numerous female and two male specimens collected at Austin, Texas, in the nests of *Eciton cœcum* Latr. and *Eciton schmitti* Emery, from October to February, the males only in February.

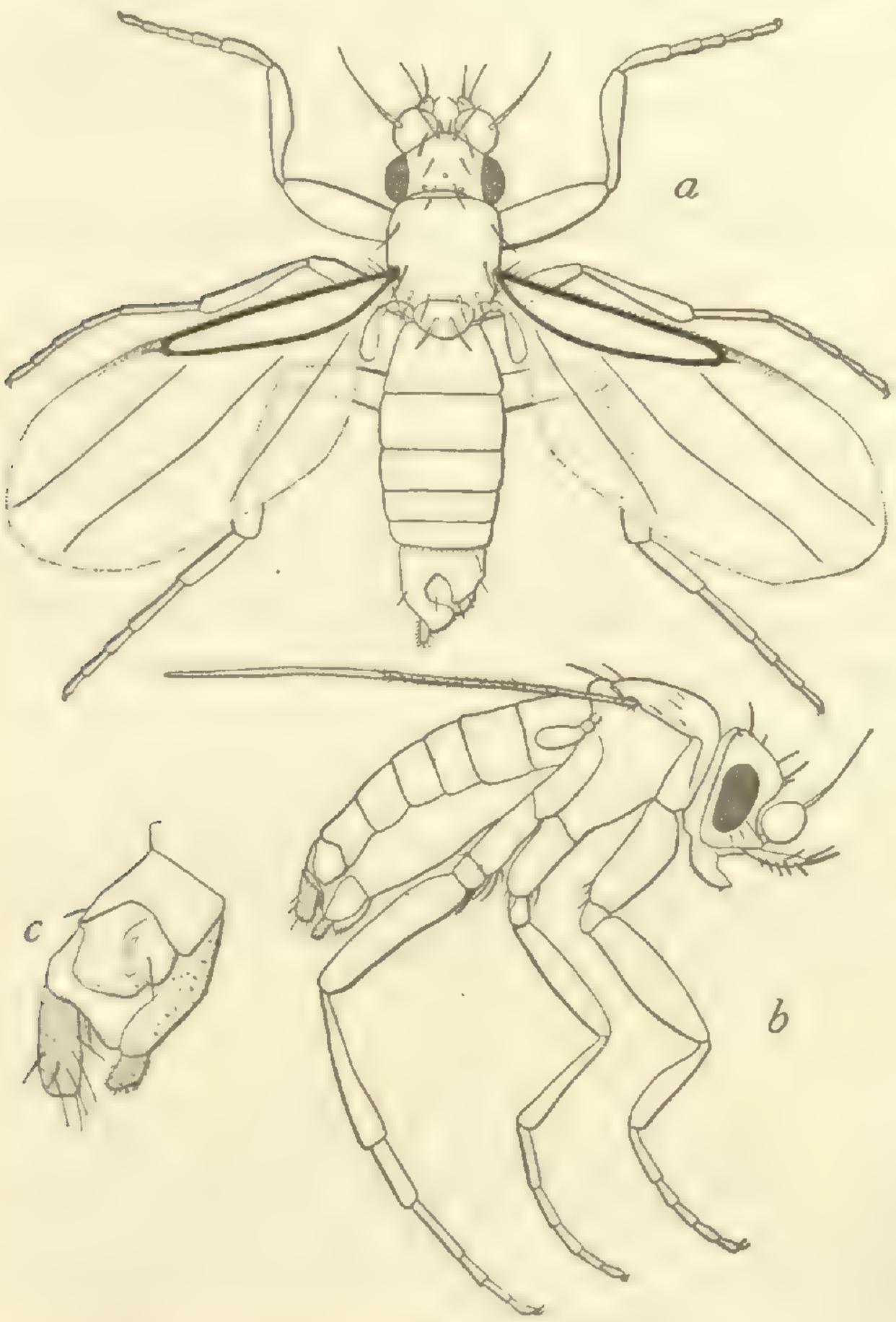

FIG. 10.—*Ecitomyia wheeleri*, n. sp., ♂. *a*, dorsal view; *b*, side view; *c*, hypopygium.

The head of Ecitomyia is much as in Commoptera, but is sharply angled at the posterio-lateral corners and longer on the vertex. The palpi are flattened and appear much thicker when seen from above. The eyes are considerably smaller than in Commoptera. The thorax is much wider than long and has no scutellum, while the metathorax is wholly concealed in the basal part of the abdomen. The appendages upon the dorsum of the thorax in the female of this species do not seem to be homologous with the similarly placed ones in Termitoxenia. They approach more closely to wings, while those in Termitoxenia are, in structure at least, like the halteres of Commoptera. That these appendages are wings is proved by their insertion evidently anterior to the meso-metapleural suture, and still more positively by their structure, as the homology of the thoracic segments is somewhat obscure. They are strap-shaped, and not round in cross-section; the dorsal side is

bristly while the ventral side is bare; they show no traces of any separate segments and articulations, whereas the halteres of Commoptera do. The presence of wings and absence of halteres are peculiar to this genus among all Diptera. Wings are often absent and rarely both wings and halteres, but in no other case are wings present without halteres. In *Ecitomyia browni* Kellogg ('00) the wings are much as in Ecitomyia, but the halteres, although somewhat reduced, are distinct. In Termitoxenia Wasmann considers the appendages of the thorax to be attached to the prothorax, which he believes to be greatly enlarged and to cover the dorsum of the entire thorax. This would certainly be an unusual development of the prothorax, and it seems much more reasonable to suppose that they are the halteres, or perhaps possibly reduced wings. It seems highly improbable that a dipteron prothorax should have suddenly become so large and have developed wing-like appendages. On the other hand, they are quite similar to the halteres of Commoptera, and Wasmann's appendices thoracicales could be easily derived from halteres. In Termitoxenia they seem to have taken on a new function, at least Wasmann so supposes from their peculiar form. He suggests that they may be of use as a means of attaching the animal to the body of the termite in order to be carried about.

The abdomen has somewhat larger dorsal plates than Commoptera, but they are nevertheless very much reduced, being scarcely visible from the side. The pit and papilla upon the anterior part of the fourth dorsal plate are shown in sections to be connected with a remarkable gland in the abdomen. The dorsal plate of the segment is continued forward to form a strongly chitinized ring which passes over into the plate posteriorly. Inside of this ring the integument is very thin and delicate, and is folded in to form a pit, surrounded on all sides by firm chitin. The bottom of the depression is swollen out in the middle to form a papilla, which is evidently to some extent eversible, as it shows a different form in almost every specimen. It often appears distinctly bifurcate at the tip. The tip of the papilla is covered with fine hairs and usually shows some refractive granules, most probably urates of some sort.

Internally the gland has a peculiar and complex structure (Fig. 11). The secretion seems to be formed in two elongate oval bodies lying in the dorsal part of the abdomen, and it is apparently carried through some intermediate, somewhat reticulately arranged cells to the surface of the papilla, which is lined with several layers of cells of varied size and form. The gland may perhaps supply some pleasant secretion for the ants, like the tufts of hairs developed in myrmecophilous Coleoptera, although I have not been able to decide by observation. I can find no reference to similar glands in any other insect, and hope at some future time to study them in detail.[1]

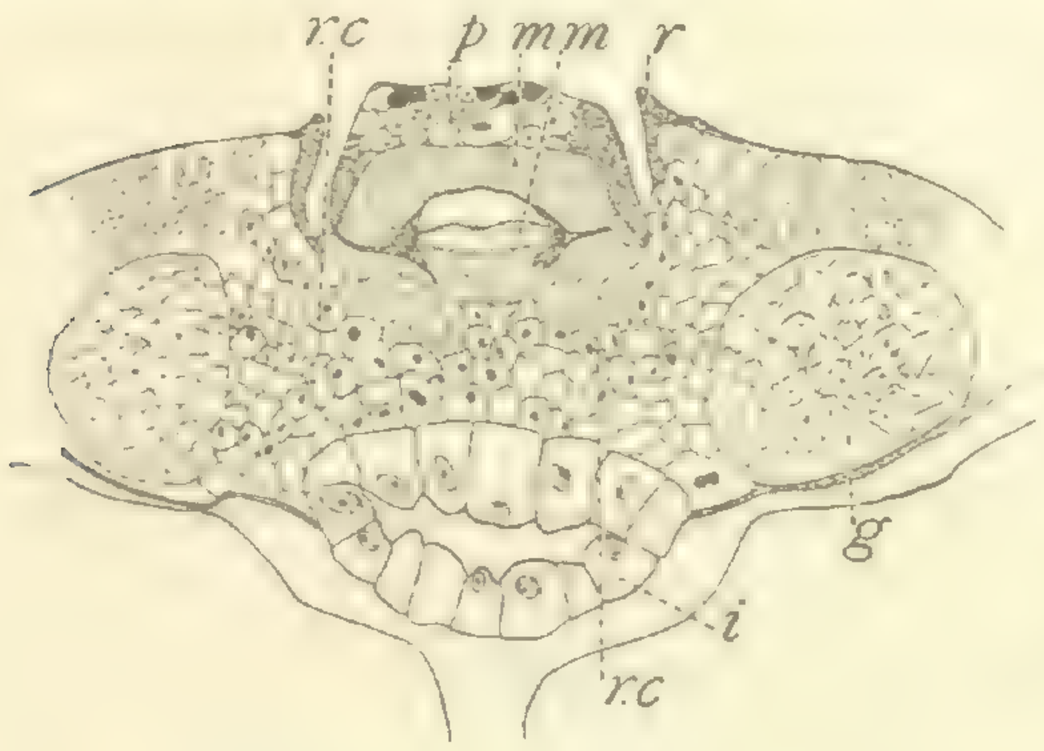

FIG. 11.—*Ecitomyia wheeleri*, n. sp. Cross-section of abdomen through gland. *g*, gland proper; *r.c*, reticulate cells; *r*, chitin ring; *p*, eversible papilla; *m*, membrane covering papilla and extending into abdomen; *i*, intestine.

We have found this species a great number of times, always associated with species of the ant genus Eciton. *Eciton cœcum* Latr., a totally blind species, which tunnels in the earth, seems to be its favorite host, although we found it upon one occasion in a nest of *E. schmitti* Emery, a species with very different habits, which lives in compact masses under stones, making its trips in search of food above ground.

The Ecitomyias are exceedingly quick and have the habit of darting rapidly about in zigzag paths in the way characteristic of many myrmecophiles. In the nests of *E. cœcum* they frequent those parts of the nest containing the greatest number of ants, being very often seen running along the galleries of the ants, into which they rapidly disappear when the nest is disturbed. Those occurring with *E. schmitti* seem to stay at a greater distance from the main body of the ants, but this species makes

[1] A very curious coincidence occurs in a new genus of wingless Proctotrupidæ which occurs in the nests of *Eciton cœcum*. *It also possesses a sharply defined roughening of the integument at exactly the same place that the gland of Ecitomyia has its opening!* I am sure, however, that there is no gland in connection with it. Can it be possible that this has any connection with some way these blind ants may have of recognizing their habitual nestmates?

large clusters and it might be dangerous for a myrmecophile to venture into these. It apparently prefers to move about in the vacant galleries of the nest.[1]

Some females which were placed in an artificial nest containing a number of *E. cæcum* workers soon made themselves at home and appeared much more at ease than the ants, which appear to be quite stupid and slow in adapting themselves to new conditions. Some of the flies preferred to rest upon the glass walls of the nest away from the ants. Others darted among the ants in the largest groups, while the ants regarded them without the slightest animosity. Any other fly or small insect introduced into the nest was viciously attacked by the ants and soon killed to serve as food for a large group of ants which had taken part in its destruction. Even dead legs and wings were picked up and carried about. Some Ecitomyias, however, which had presumably died a natural death, were not molested by the ants, and remained for a long time undisturbed. One of the Ecitomyias was apparently feeding upon some deposit left by the ants as they moved about, and it also approached some of the less excited ones after the manner of Myrmecophila, but I could not see that it obtained anything from the bodies of the ants.

Throughout the winter we had seen the females in almost every large nest which we examined, but although probably half a hundred nests were seen during that time, not until February did we positively find any males. In a large flourishing nest of *E. cæcum* which extended under stones for a distance of nearly twenty feet, we found numerous female and two male specimens. Although the male has ample wings, it did not attempt to fly, but hopped about in a similar but much less agile manner than the female, which is often exceedingly quick and hard to catch. The male does not hold the wings flat

[1] We have not been able to observe how they manage to follow the ants about as they make their regular changes of nest, for this ant does not remain in the same nest for any length of time, except probably during the breeding season. Other myrmecophiles of this species (*e.g.*, Staphylinidæ) march along in procession with their hosts as they make their curious journeys. As *E. cæcum* moves only by tunneling underground, they would experience no difficulty in keeping company with the ants.

upon the back, but keeps them in a slanting position, so that it resembles an exceedingly small aphid or psocid.

TERMITOXENIA WASMANN.

Thorax with one pair of dorsal appendages, apparently the halteres. Proboscis two-jointed, much produced, styliform or rostriform. Labrum with a styliform appendage anteriorly. Eyes small, ocelli very small. Halteres styliform or hooked at tip. Abdomen much swollen, curved downwards, anus directed forward.

This most remarkable genus is represented by four termitophilous species from Africa and India (Wasmann, '00a). Only females are known, although Wasmann considers some of his specimens as hermaphrodites, as they apparently possessed both ovaries and testes. He says, in speaking of *T. mirabilis*: "Jetzt sehe ich an Schnittserien der letzteren, dass dieselben Hermaphroditen sind mit noch kleinen ovarien und gut entwickelten Hoden." On such evidence we must not, however, suppose that winged males do not occur. Other cases of hermaphroditism among insects have been noted, but in no case is it established to be anything more than a pathological condition of certain individuals.

STETHOPATHUS WANDOLLECK.

Both wings and halteres absent, ocelli present, epistoma not large and prominent. Thorax rounded. Abdomen elliptical, first four dorsal segments strongly chitinized and well developed, covering the greater part of the dorsum of the abdomen. Abdomen not greatly retractile at apex, ovipositor short.

Only one species of this genus has been described, *S. ocellatus* Wand. from the East Indies. The specimens were found upon carrion and in the flowers of the giant Arum (Amorphophallus).

It was previously described by Dahl as the female of his *Puliciphora lucifera*, but because of his poor description and misunderstanding of its systematic position, Wandolleck redescribed it under a new name which it is probably best to adopt.

Chonocephalus Wandolleck.

Wings and halteres wanting, ocelli wanting, eyes small and sunk deeply into the head. Front almost horizontal. Thorax in profile triangular. Abdomen elliptical, with six strongly chitinized dorsal plates which extend far down upon the sides. Sixth ventral plate also present, almost meeting the sixth dorsal. Ovipositor long.

This genus is represented only by *C. dorsalis* Wand., from the Bismarck Archipelago. The imagines were found upon carrion.

In conclusion, I wish to express my greatest thanks and gratitude to Dr. Wm. M. Wheeler for the many kind suggestions and great help which he has given me throughout my work. I take great pleasure in naming one of the species in his honor as a slight token of my appreciation.

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UNIVERSITY OF TEXAS, AUSTIN,
March 1, 1901.

POSTSCRIPT.

After this article had gone to press, the author was so fortunate as to obtain two other new species of Stethopathinæ, even more remarkable than the ones described above. While collecting ants in the vicinity of Austin with Mr. A. L. Melander one afternoon during March, we found in a nest of *Eciton opacithorax* Emery a small insect which by its actions was at once recognized as a member of the Stethopathinæ. On carefully sifting the earth of the nest a second specimen was obtained. On comparing them we were exceedingly surprised to discover that not only were they different from any described Stethopathinæ, but were also quite unlike each other. They are both females which I intend to describe in the near future as representatives of two new genera. From this it would seem that there must be a whole series of these peculiar Diptera living as true myrmecophiles in the nests of various ants.

UNIVERSITY OF TEXAS, AUSTIN,
April 10, 1901.

THE METATHORACIC PTERYGODA OF THE HEXAPODA AND THEIR RELATION TO THE WINGS.

L. B. WALTON.

On the anterior margin of the prothorax and mesothorax of the Lepidoptera are two small sclerites known as the patagium and tegula, respectively; while in certain other orders of Hexapoda (Hymenoptera, Neuroptera, and Trichoptera) a small piece has been found at the base of the mesothoracic wing which has been considered equivalent to the tegula. Further than a few suggestions based on limited observations, no attempt has been made either to ascertain the value of these pieces or to demonstrate the existence of similar homodynamous or homologous structures in the hexapods.

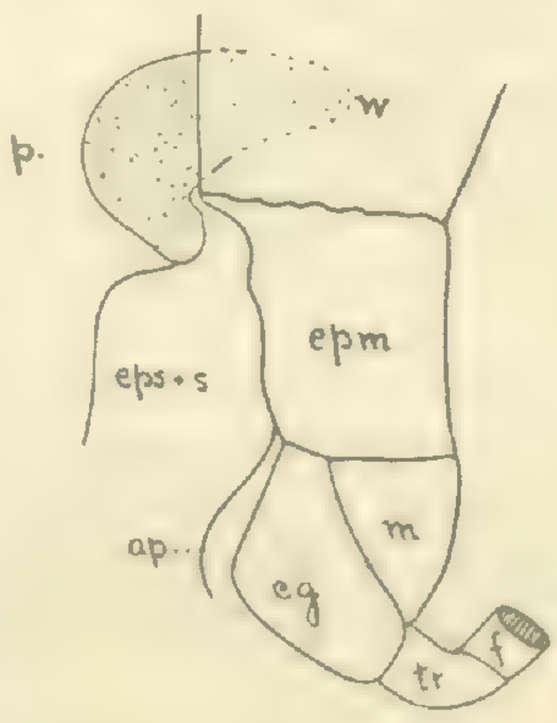

FIG. 1.—*Cossus ligniperda.* Left lateral portion of mesothorax. × 8. *p*, pterygodum (stippled); *w*, wing; *eps*, episternum; *epm*, epimeron; *cg*, coxa genuina; *m*, meron; *s*, sternum; *ap*, antecoxal piece; *tr*, trochanter; *f*, femur. Cut portion of femur represented by parallel lines. Dotted line shows pterygodum extending behind the anterior wing. All figures are placed in the same relative position, so that the upper margin represents the dorsal part of the thorax, while the margin at the left is the anterior portion of the thorax.

The purpose of the present paper is to call attention briefly to the general presence of a sclerite on the hexapod metathorax which seems homodynamous with the so-called tegula, to make some suggestions concerning terminology, and especially to point out that the present view concerning the metamerism of the antennate arthropods appears worthy of reconsideration.

The relation of the tegula, or pterygodum as I prefer to term it, to the pieces of the mesothorax, which is in many respects the most generalized of the three thoracic segments in the insects, is shown in Fig. 1. Bearing in mind now that the mesothorax and metathorax are equivalent,

the various components of each being reduplicated in the other segments, subject, however, to the factors governing the specialization of the different groups of insects, the existence of a corresponding piece in the metathorax would *a priori* be inferred. The presence of such a piece[1] is represented in the accompanying diagram (Fig. 2), while a homologous part can generally be demonstrated throughout the other orders (Figs. 3, 4). Furthermore, it is to be noted that in the typical form this is joined to the dorsal margin of the episternum, while the wing is articulated with the dorsal margin of the epimeron and not, as hitherto accepted, with the episternum.[2]

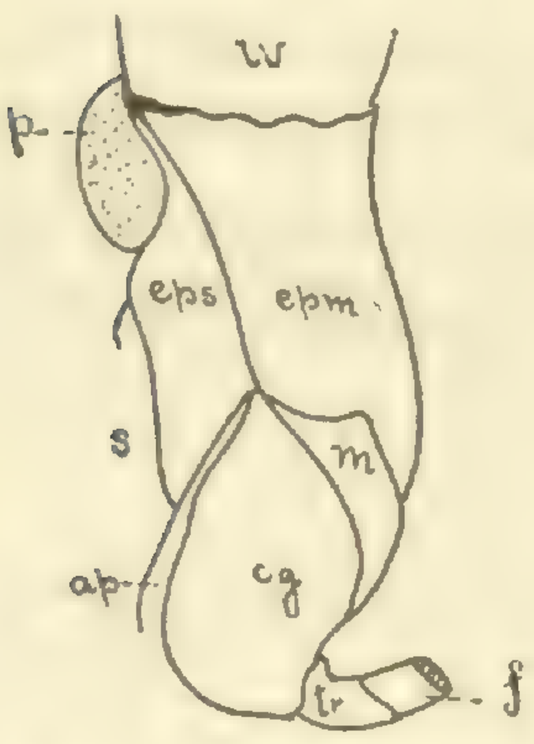

FIG. 2.—*Cossus ligniperda*. Left lateral portion of metathorax. × 8. References as in Fig. 1.

In connection with the facts noted above, certain evidence is available, based on embryology as well as comparative anatomy, which adds weight to the inference that these two pieces are rudimentary[3] wings and that the *thorax of the Hexapoda is composed of six somites which in the typical form bear the fundaments of six pairs of wings.*

The development of the mesothoracic pterygodum[4] (=tegula, parapteron, etc.) is of extreme interest in this connection and furnishes interesting evidence toward establishing the hypothesis I have put forward regarding its relation to the wing. This, however, is only one of a large number of facts which corroborate such a view and which appear explainable on no

[1] From comparisons made throughout the Hexapoda it is evident that this does not correspond to the more or less chitinized part of the epimeron at the base of the wing in most Lepidoptera.

[2] The anterior margin of the wing is generally specialized at the base, so that it partially extends over the dorsal portion of the episternum, while an articulative process of the pterygodum may be received into a corresponding notch of wing. (See Fig. 3.) This condition, however, is secondary.

[3] There appears to be no evidence for regarding these as vestigial, since it is improbable that forms with six pairs of wings ever existed. The term "rudimentary," as generally used, does not seem inappropriate, although the word "fundament" is more concise.

[4] Owing to its greater size, this can be more conveniently studied than the corresponding piece on the metathorax.

other basis. To one of these I have already called attention (Walton, **1900**), notably the formation of the coxa in Chilopoda and Hexapoda from two fused pieces to which I have applied the name "coxa genuina" and "meron."

I have adopted the name "pterygodum"[1] for the present in preference to others which have been suggested for the mesothoracic piece (tegula, parapteron, squamula, etc.), since it has priority over terms otherwise acceptable, and according to our present knowledge better indicates the function of the part. The term "parapteron," which Comstock and Needham ('**98**), following Newport ('**39**), have used in reference to the mesothoracic pterygodum, appears inappropriate, for the reason that Audouin ('**24**) first used it to indicate a supposed sclerite on the anterior margin of the mesothoracic episterna in *Dytiscus circumflexus*, the part in question being merely an articulative process. Several years later, in a note to a translation of a paper by MacLeay ('**32**), Audouin stated his belief that the piece in the Hymenoptera termed squamula by MacLeay was homologous to the parapteron which he himself had described. This supposition was not only incorrect but was subsequent to the terminology adopted by Latreille.

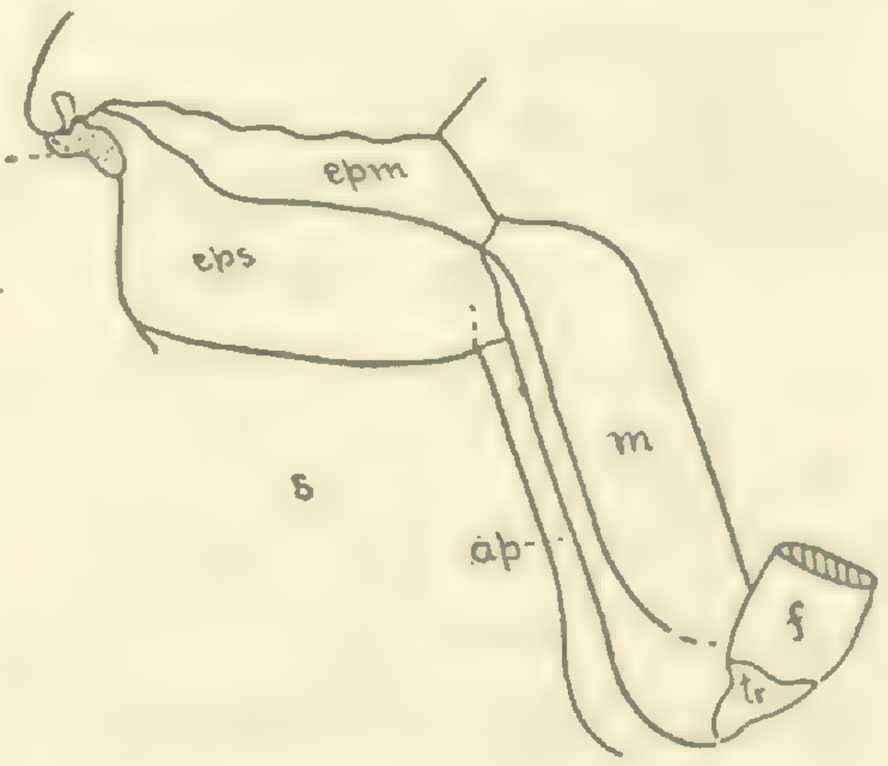

FIG. 3. — *Hydrophilus triangularis*. Left lateral portion of metathorax. × 8. Coxa genuina between ante-coxal piece and meron. Other references as in Fig. 1. Wing above epimeron, unlettered.

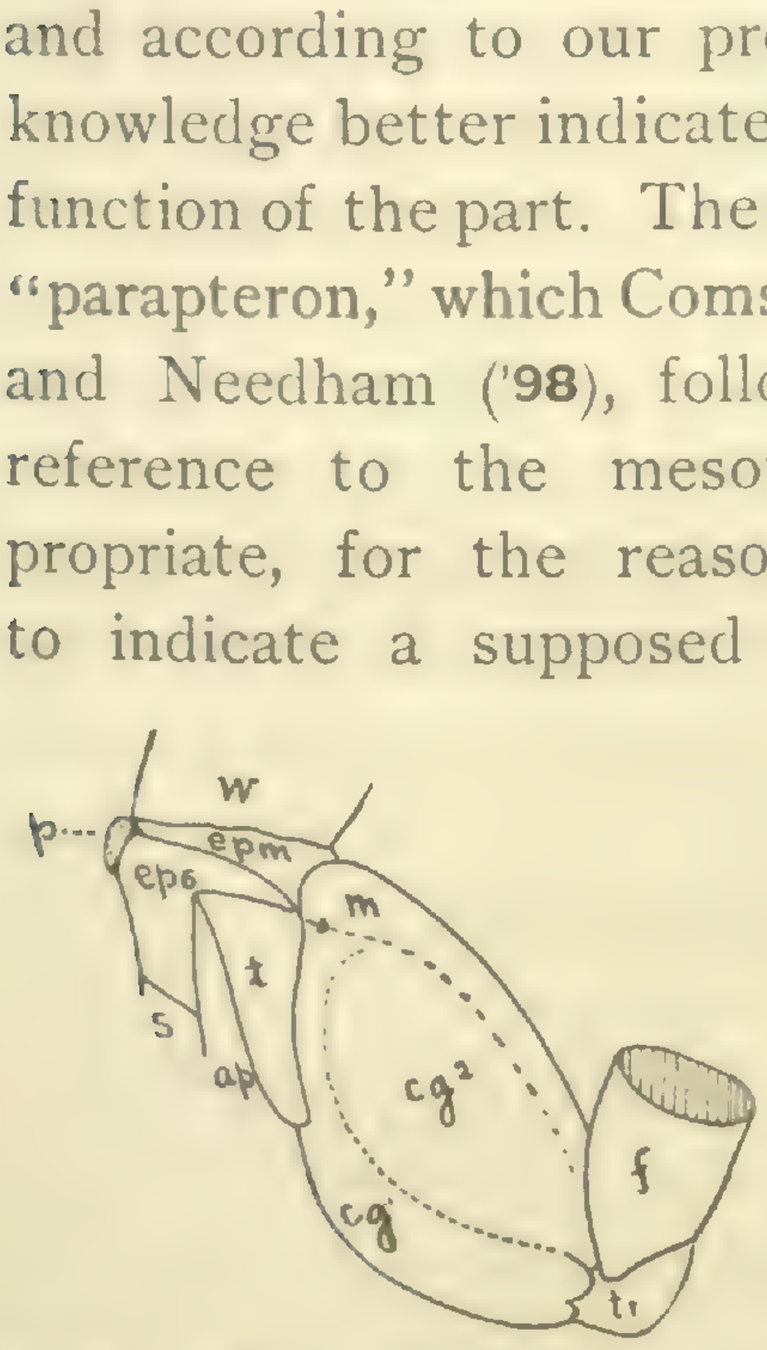

FIG. 4. — *Periplaneta orientalis*. Left lateral portion of metathorax. × 10. cg^1, anterior portion of coxa genuina; cg^2, posterior portion of coxa genuina, formed by the coxal groove for reception of femur; *t*, trochantin. Other references as in Fig. 1.

The value of the patagium on the prothorax has been more or less discussed, but until we know more concerning its development it is impossible fully to decide whether it is equivalent

[1] ‹gr. πτερυγώδης ‹πτερυγοειδής = πτέρυγος [wing] + εἶδος [form].

to the wing, as suggested by Cholodkowsky ('86), or to the pterygodum (tegula), the view adopted by Haase ('86) and now so generally accepted. It should be observed, nevertheless, that the reasons given by Haase for reaching such a conclusion are far from adequate, since the only evidence to which he called attention, otherwise than a superficial resemblance, was that (1) chitinous folds of a similar nature but of secondary origin are present on the prothorax of certain Hymenoptera and Diptera, while (2) the patagia do not exist during the larval stage of the Lepidoptera, but commence their development in the first few days of the chrysalid stage. Unfortunately, however, Haase failed to demonstrate any homologous structures in the Hymenoptera or Diptera, and had he attempted to do so it is evident, from the preceding, that proof of their secondary nature would have been difficult to establish. Moreover, the Anlage of a structure must exist *in potentio*, and the time during the post-embryonic stages at which it commences that which is known as development can alone be of no particular value in determining its palingenetic or cenogenetic character. The question as to whether the patagium represents a prothoracic pterygodum or a wing, must await a large amount of comparative work based on embryology, with the possibility of paleontological[1] evidence affording some help in the solution of the problem. The ratio of development between wing and pterygodum on the other thoracic segments allows the inference, however, that pterygoda may

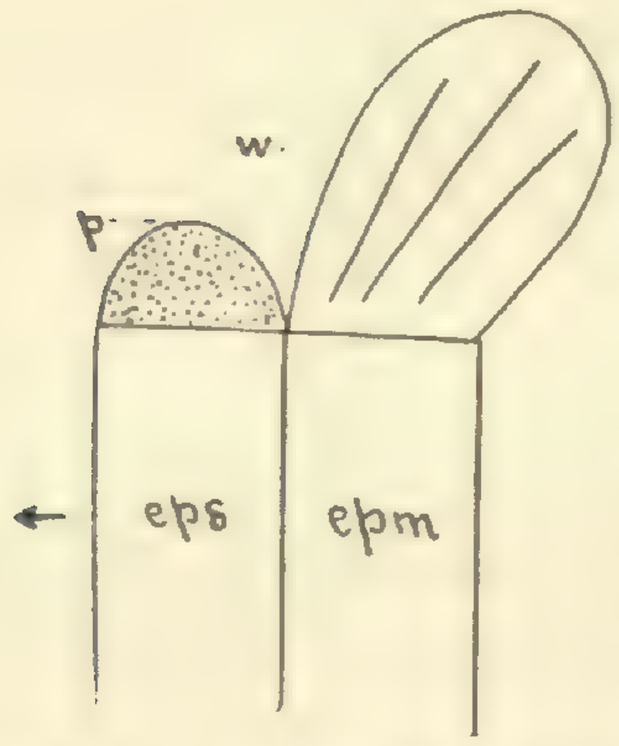

FIG. 5. — Typical form showing relations of pterygodum, wing, episternum, and epimeron in the thoracic segment of the Hexapoda. References as in Fig. 1.

[1] The prothoracic appendages of certain fossil insects (*Homoioptera woodwardi*, *Stenodicta lobata*, *Lithomantis goldenbergi*, *carbonaria*, etc.) so excellently figured by Brongiart (*Recherches pour servir à l'histoire des insectes fossiles*, Paris, 1894) cannot be homologized with the expanded margin of the prothorax in existing Mantidæ, as Woodward (*Quart. Journ. Geol. Soc.*, vol. xxxii, p. 60, London) suggested. Brongiart has already pointed this out. (Note sur quelque insectes fossiles du terrain houiller qui presentent au prothorax des appendices aliformes, *Bull. Soc. Philom.*, tome ii, 1890.)

exist in front of the patagia which then have the value of wings.

Another interesting question in this connection is the homology of the elytra of Coleoptera, for again further investigation must be awaited before a logical conclusion can be reached. The tracheation of the elytra, to which attention has been called by Comstock and Needham ('98), is not conclusive evidence that they are specialized wings, for in connection with the view I have here advocated this would be expected if they were homologous with the mesothoracic pterygoda of the Lepidoptera, and the suppressed wing was represented by the alulet so noticeable under the Elytra in Hydrophilus, etc.

From the preceding facts, to which I have called attention, it appears necessary to consider that the typical thoracic segment (Fig. 5) possesses the components of both pterygodum and wing, the former joined to the dorsal margin of the episternum, the latter articulated with the dorsal margin of the epimeron, while furthermore the morphological position of the pterygodum in respect to the wing indicates that it may have an important bearing in elucidating the metamerism of the antennate arthropods.

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PHAGOCYTOSIS IN THE POSTEMBRYONIC DEVELOPMENT OF THE DIPTERA.

VERNON L. KELLOGG.

In the most recent considerable[1] paper on the postembryonic development of an insect of complete metamorphosis, the author lays much stress on the small part which phagocytes play in the breaking down of the larval tissues during the metamorphosis of the insect studied — the little brown ant, *Lasius flavus*. In this respect the author sees in the metamorphosis of Lasius (belonging to the Hymenoptera) a sharp contrast to the metamorphosis of the Diptera, in the best-known example of which, the much-studied Calliphora, phagocytosis plays an all-important part. Korotneff[2] found in the case of the degeneration of the larval muscles of Tinea (Lepidoptera) that there was no phagocytosis. Rengel,[3] in studying the changes in the alimentary epithelium of Tenebrio and other Coleoptera, found also no phagocytosis, and Needham,[4] in a careful study of the flag weevil (*Mononychus vulpeculus*), similarly found a complete lack of phagocytosis in the histolysis of the larval tissues of this insect. Karawaiew strongly agrees with Korotneff and Rengel in believing that phagocytosis is a phenomenon of postembryonic development associated with the length of time occupied by the metamorphosis. With the blowfly the metamorphosis occupies but a few days; with Tinea, a little more than two weeks; with Tenebrio, several weeks, according to the temperature; and with the ants still

[1] Karawaiew, W. Die nachembryonale Entwicklung von Lasius flavus. *Zeitschr. f. wiss. Zool.*, Bd. lxiv (1898), pp. 385–478, Pls. IX–XII, and 15 figs. in text.

[2] Korotneff, A. Histolyse und Histogenese des Muskelgewebes bei der Metamorphose der Insekten, *Biol. Centralbl.*, Bd. xii (1892), pp. 261–265.

[3] Rengel, C. Ueber die Veränderungen des Darmepithels bei Tenebrio molitor während der Metamorphose, *Zeitschr. f. wiss. Zool.*, Bd. lxii (1896).

[4] Needham, J. G. The Metamorphosis of the Flag Weevil (Mononychus vulpeculus), *Biol. Bull.*, vol. i (1900), pp. 179–191.

longer; in the case of *Lasius flavus*, for example, from the first warm spring days until the beginning of June or even longer. In the case of the insects, like the flies, with a short time devoted to metamorphosis, there must be space made for the new organs as quickly as possible; that is, the old larval organs must get out of the way as soon as may be. The natural process, a gradual degeneration, is a process of long duration, and on that account not sufficient in the case of the flies. Hence, says Karawaiew, there has arisen the barbaric devouring of the tissues by the leucocytes.

It has seemed to me unfortunate that in the study of the postembryonal development of the Diptera so much attention should have been given to the highly specialized Muscidæ and so little to more generalized members of the order. The metamorphosis of Coretha, Culex, and Chironomus has been studied somewhat, but without any approach to that exhaustiveness which characterizes the studies of Weismann, Van Rees, Kowalevsky, *et al.*, on Calliphora. In the hope of finding some new light upon these extraordinary phenomena of histolysis and histogenesis which are a part of insect metamorphosis I have undertaken the study of the postembryonic development of two flies belonging to the more generalized Diptera, the Nematocera. One of these flies is *Blepharocera capitata*, a member of the strange, small family, Blepharoceridæ, with strangely and strongly modified immature stages, and the other is *Holorusia rubiginosa*, a giant crane fly (Tipulidæ), with simple immature stages. While both of these forms are nematocerous Diptera, and to this extent allied, there is an exceptionally wide divergence between them in point of structure of the larval stages, and this difference has, to my mind, an all-important influence in determining the obvious and suggestive differences in the character of the development, which, we shall see, obtains. This present reference to the metamorphosis of these two dipterous forms has to do solely with the peculiarly interesting and suggestive conditions of the histolytic processes in the metamorphosis.

The larva of *Holorusia rubiginosa*[1] is cylindrical, worm-like, tapering slightly towards both ends, without feet or other special organs of locomotion. It attains a length of three inches (outstretched full-grown specimens). The head is a retractile, strongly chitinized capsule, with biting mouth-parts. The internal anatomy is simple. The musculation consists, except in the head, of simple segmental, longitudinal, integumental muscles and of annulate integumental muscles. Locomotion is a simple squirming or wriggling, caused by longitudinal contractions. The alimentary canal is a straight tube divisible into the usual parts. The ventriculus has four diverticula or cæca, and the large intestine has a single forward projecting diverticulum. There are four Malpighian tubules. There is a single pair of large salivary glands, each gland bent double. The respiratory system consists of a single pair of large spiracles situated on the posterior aspect of the last abdominal segment, and of a pair of main longitudinal tracheal trunks with their branches. The larval life lasts several weeks.

The pupa is found in the same place inhabited by the larva, and is of simple character. It is from one and one-fourth to one and three-fourths inches long. There is a pair of slender, short respiratory tubes on the prothorax. The pupal stage lasts twelve days.

In the course of the postembryonic development of Holorusia I have found no occurrence of phagocytosis. The breaking down of the muscles and salivary glands and fat body of the larva (tissues in which phagocytosis most certainly occurs if at all and in which it is most readily determinable) is accomplished apparently entirely by simple "*selbständige Degeneration*" (Karawaiew). The breaking down of the muscles does not begin until after the pupal life is well started. In fact there is no very great breaking down essential. The musculation of the adult differs from that of the larva more in the addition of the wing and leg muscles of the thorax

[1] This is the first published reference to the immature stages of this giant tipulid. The larvæ were found abundantly on the banks of a small stream near this university (Stanford), lying in mud and slime composed of decaying leaves.

and the muscles of the head than in any complete substitution of an imaginal musculation for a previous wholly different complex larval musculation. In pupæ one-third through their existence (four days old) a great deal of the larval musculation still persists side by side with the developing new muscles of the thorax. The nuclei of the degenerating larval muscles show the "old-age" characters of degenerating nuclei; the contractile substance first loses its striate appearance, then becomes loosely fibrous, then spongy, and finally breaks up.

The degeneration of the large salivary glands is easily followed. In the larvæ the nuclei of the large epithelial cells

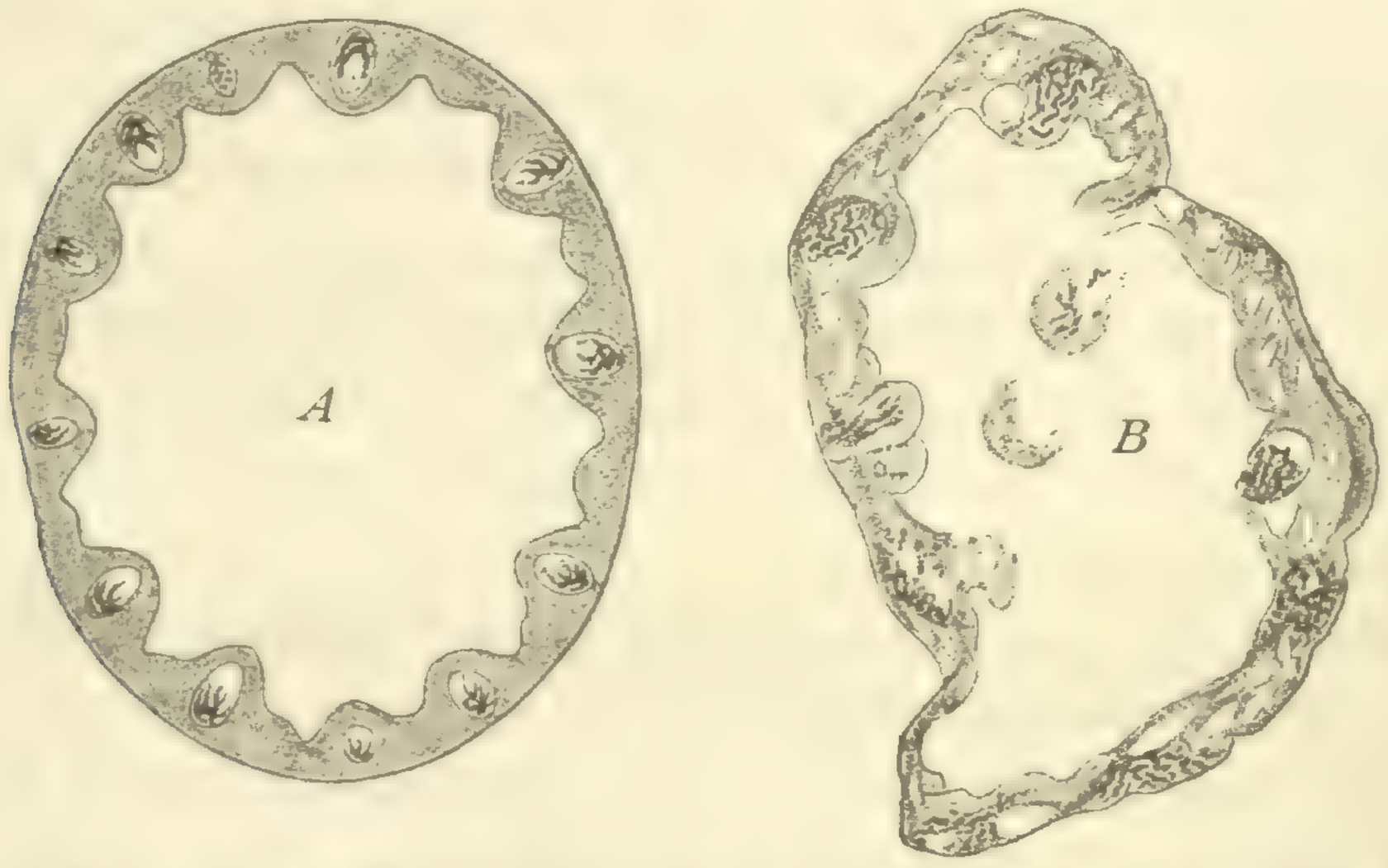

FIG. 1. — Salivary gland of *Holorusia rubiginosa*: *A* cross-section of gland of larva; *B*, cross-section of gland in pupa forty-eight hours old, degeneration being well advanced.

are regularly circular or elliptical (in optical plane) and sharply delimited by a nuclear membrane. The chromatin is rather massed together and stains strongly. The cytoplasm of the cells is evenly granular and the cell outlines well defined (Fig. 1, *A*). In a pupa not more than twenty-four hours old a marked degeneration of the cells has occurred. The cytoplasm is distinctly vacuolated, and in a pupa a day or two older the cytoplasm is spongy, the cells have lost their shape, the nuclei have lost their membranes and are showing other degenerative characters (Fig. 1, *B*). No phagocytes appear. The degeneration or histolysis of the larval tissues of Holorusia is accomplished thus without the interference of phagocytes. The pupal condition is characterized by no such extensive breaking down

of larval organs as is apparent in the pupæ of Calliphora, where the pupal body cavity is filled with "pseudo-yolk," a confused fluid mass of degenerating tissue.

The larvæ of *Blepharocera capitata*[1] are of extraordinary external appearance, and in their habits and structure are widely removed from other dipterous larvæ. They live under water in brooks, clinging by six elaborately developed ventral suckers to the smooth rock bed or to smooth stones in parts of the stream where the water runs swiftly and is shallow. The segments of the body are greatly modified, the three thoracic segments and the head being fused to form a single large anterior body region. For the control of the suckers and for the peculiar lateral swinging movement of the body in locomotion an elaborate musculation is developed, which is very different from the musculation of the adult fly. The pupæ are also extraordinary in character and live, like the larvæ, attached to the rocks in swift, shallow parts of the stream. The duration of the pupal stage is fifteen days. The histolysis of the larval tissues begins three or four days before the true pupal condition is reached. The larvæ cease feeding, become quiet, and thus remain three or four days before pupation. The total duration, therefore, of the time devoted especially to the change from larva to imago is about eighteen days, as compared with twelve in the case of Holorusia.

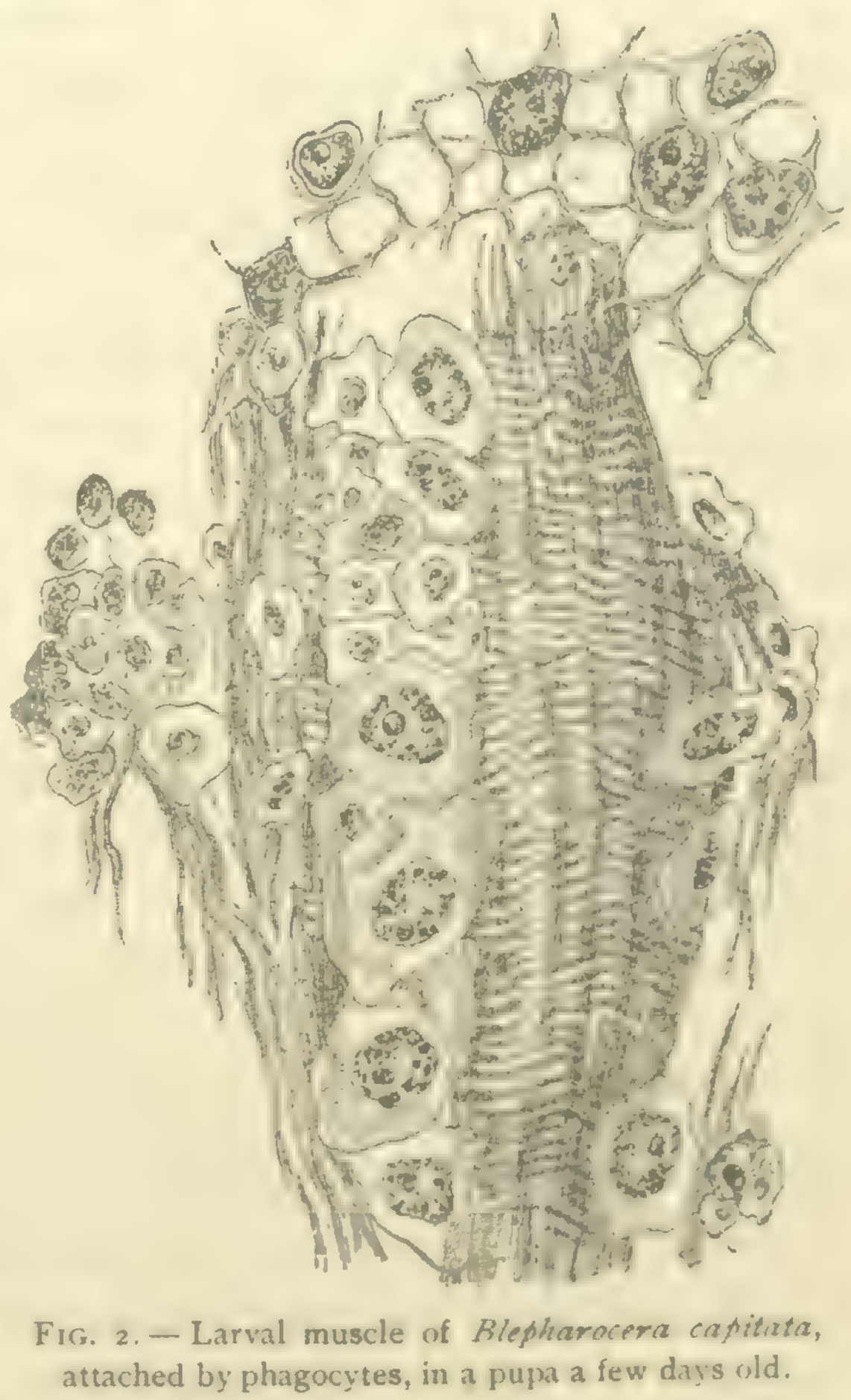

FIG. 2. — Larval muscle of *Blepharocera capitata*, attached by phagocytes, in a pupa a few days old.

[1] For an account of the structural character of the larvæ, see Kellogg, Notes on the Life-History and Structure of Blepharocera capitata Loew, *Ent. News*, vol. xi (1900), pp. 305–318.

There is a great breaking down of the larval organs of Blepharocera. With such a specialized larval life there is a great difference between the larval organs and the imaginal organs. The musculature, the alimentary canal, and the respiratory system are largely broken down and reformed. And in all of this histolysis phagocytes are abundant and conspicuous. When pupæ not more than three or four days old are dissected, the body cavity is found to be filled with "pseudo-yolk," that is, with a lymph-like liquid containing floating bits of degenerating tissue and hosts of phagocytes. A bit of larval muscle (Fig. 2) in a pupa a few days old shows very well the character and effects of the phagocytosis.

Thus in the fly Blepharocera, with its eighteen days of prepupal and pupal condition, phagocytosis is conspicuously present; in the fly Holorusia, with its twelve days of pupal condition, histolysis is unaccompanied by phagocytosis. The fly in which the histolytic phenomena occupy the longer time is the one in which the histolysis is accompanied by phagocytosis. This is a condition not at all in consonance with Karawaiew's conclusions, as quoted at the beginning of this paper.

What is the reason for the presence of phagocytes in the histolysis of Blepharocera and their absence in Holorusia? To my mind, the extent of the metamorphic changes, the degree to which histolysis occurs, probably offers the explanation. In Blepharocera, with its highly specialized larval form, its peculiar and specially developed organs, the change to imago is radical; the histolysis of larval tissues is extensive. In Holorusia, with its generalized larval form, its less modified organs, the change to imago is accomplished with much less breaking down of larval organs and reformation of imaginal ones; the histolysis is less radical and considerable. The phagocytes are the agents or the assisting agents in the more extended and radical histolysis.

My observations so far do not enable me to offer any evidence regarding the moot point touching the causal agency of the phagocytes in histolysis. Whether the phagocytes initiate histolysis, or merely render effective aid after the degeneration has been initiated independently, is a question of importance.

ON THE SIGNIFICANCE OF THE SPIRAL SWIMMING OF ORGANISMS.[1]

H. S. JENNINGS.

It is a well-known fact that many of the lower organisms swim in a spiral path, but the real significance of this fact has never been pointed out, I believe, until recently. Swarmspores, flagellate and ciliate infusoria, rotifers, and many other lower organisms as they pass through the water revolve on their long axes, and thus follow a course that takes the form (as a rule) of a spiral. Extended discussions of this fact are to be found in many works, as in Bütschli's "Protozoen" in Bronn's *Klassen und Ordnungen des Thierreichs*, and in many special papers. These discussions usually confine themselves to a description of the facts, — so far as these were made out, — and to a discussion of the mechanical factors involved in producing the spiral movement, without any attempt to show the biological significance of the phenomenon. To understand the significance of this method of swimming was indeed perhaps impossible until the relation between it and the method of reaction to a stimulus in these organisms was known, and especially until it was recognized that *the body of the organism bears a constant relation to the axis of the spiral*, — that is, that the same side of the organism is always directed toward the outside of the spiral (as in Fig. 1). These relations were first pointed out by the present writer in Nos. II and V of his "Studies on Reactions to Stimuli in Unicellular Organisms,"[2] where they were shown to hold for a considerable number of Flagellata and Ciliata.

[1] The substance of this paper was presented at the meeting of the Western Naturalists in Chicago, Dec. 27, 1900.

[2] II, The Mechanism of the Motor Reactions of Paramecium, *Am. Journ. of Phys.*, vol. ii (1899), p. 323; V, On the Movements and Motor Reflexes of the Flagellata and Ciliata, *Am. Journ. of Phys.*, vol. iii (1900).

The exact purpose that is served by this method of swimming is a point deserving of further emphasis and fuller discussion. The Flagellata and Ciliata are as a rule unsymmetrical in form. One of these organisms, as, for example, Loxodes (Fig. 2), or Paramecium (Fig. 3), when it leaves the bottom and starts to swim freely through the water, cannot go in a straight line, but owing to its lack of symmetry continually swerves toward one side, so that it tends to describe a circle. If no method is taken of compensating this deflection, the circles described are frequently very small, and of course the animal makes no progress by swimming in this way. Paramecium and Loxodes thus tend to circle toward the aboral side, Chilomonas (Fig. 4) toward its "lower lip," all the Hypotricha to the right, etc.

FIG. 1. — Diagram of spiral course of Loxodes when swimming freely through the water. If *a* and *c* are conceived as being in the plane of the paper, then *b* is above and *d* below this plane.

To obviate this difficulty, revolution on the long axis is combined with the forward movement of the organisms. By this means the continual swerving toward one side is compensated, since this side is continually turned in a new direction. Thus, if Loxodes is swimming (freely through the water) away from the observer, and the aboral side is at first to the observer's left (Fig. 1, *a*), the organism at first swerves to the left; but as it revolves the aboral side soon comes to be the upper side, and the animal now swerves up (*b*). By continued revolution the aboral side is brought to the right (*c*), so that the animal swerves to the right. Next, of course, it swerves down and the process is continued, the animal swerving successively to the left, up, right, down, etc. These movements, of course, compensate each other, so that only the forward component of the motion is

effective; the animal thus moves forward as if on a straight line, — the actual path being a spiral with a straight axis. The principle is the same as that by which a rifle bullet is given a straight course by making it revolve in the axis of flight.

In the Hypotricha a similar course is followed, save that the swerving is to the right; in Chilomonas (Fig. 4) it is toward the lower lip (*a*). Such a spiral path is known to be followed by most of the free-swimming Protista, — by swarm-spores, flagellates, and ciliates in general; by Volvox, Eudorina, Pandorina, Platydorina, etc. In some of these organisms the course followed becomes almost an actual straight line, owing to the fact that the body is symmetrical, so that there is no pronounced swerving toward one side. Such is the case, for example, in Volvox. Here the revolution on the long axis probably serves merely to compensate for any accidental deviations that may occur through injury, unequal development, and the like. Such cases are comparatively rare, however, most of these organisms being markedly unsymmetrical.

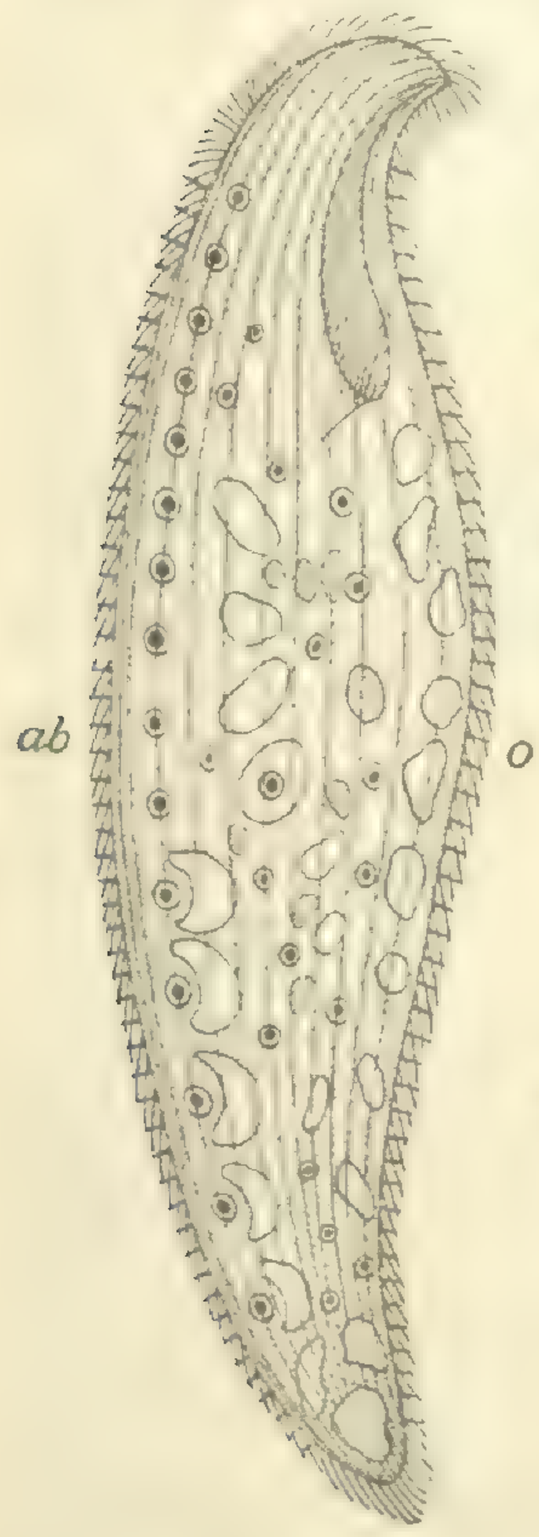

FIG. 2.

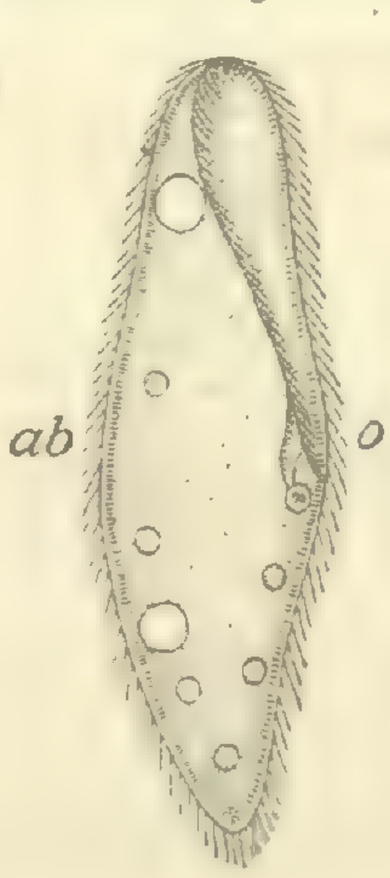

FIG. 3.

FIG. 4.

FIG. 2. — *Loxodes rostrum*, after Bütschli, showing the unsymmetrical form. *ab*, aboral side; *o*, oral side.

FIG. 3. — *Paramecium caudatum*. *ab*, aboral side; *o*, oral side.

FIG. 4. — *Chilomonas paramecium*, after Bütschli. *a*, "lower lip."

The mechanical cause of the revolution on the axis of progression has often been discussed. In the Ciliata there seem to be three possible factors: (1) an oblique stroke of the cilia; (2) the oblique position of the peristome; (3) the unsymmetrical form of the body, which is often of such a shape as to favor rotation in a given direction. That the first factor is the primary one is indicated by the fact that the direction of revolution may be reversed in many of these organisms, even when

the form of the body is such as to oppose this reversal. The unsymmetrical form seems rather an adaptation to this method of swimming, — a consequence of it. Many of these organisms are so shaped that the body forms part of a spiral; this is to a certain degree the case, for example, in Paramecium (Fig. 3). In some others this is much more marked. Phacus, for example, is frequently strongly spiral. Some of the bacteria swim in this same manner, and among these, Spirillum forms, as is well known, a sort of animated corkscrew. The prevailing asymmetry in the unicellular organisms is closely correlated with this method of swimming.

When creeping along the bottom (as Loxodes usually does), or when in contact with any solid object, these same organisms exhibit no such rotation. When moving along a surface there are, of course, only two chances to err from the straight line, either to the right or to the left. When swimming freely through the water, on the other hand, the chances of deviation are indefinitely numerous, since the organism may swerve to the right or left, or up or down, or in any intermediate direction. Moreover, when in contact with a surface, this usually presents numerous stimuli, which serve as directives of motion, while in the free water such stimuli are lacking. Hence the necessity of some special device for keeping the straight course in the latter case. The movements and reactions of organisms differ greatly when they are moving along a surface from those exhibited when passing freely through the water. (Pütter[1] has recently published a valuable paper on this subject.) Both flagellates (*e.g.*, Peranema) and ciliates move without rotation when in contact with a surface. Yet even then they usually cannot travel in a straight line; Colpidium and Oxytricha, for example, follow a much curved course.

As the present writer has fully set forth in his "Studies on Reactions to Stimuli" (*loc. cit.*), this method of locomotion is closely related with the usual method of reaction to a stimulus. In addition to swerving toward a structurally defined side in

[1] Pütter, August. Studien über Thigmotaxis bei Protisten, *Archiv f. Anat. u. Phys.*, Physiol. Abth., Supplement Band (1900), pp. 243–302.

their locomotion, these unsymmetrical organisms respond to a stimulus by turning toward a structurally defined side.

It is important not to misunderstand the nature of this spiral motion. If one of these swimming organisms is viewed from above with the ordinary microscope, the path of the organism seems to swerve merely first to the right, then to the left. This is of course because the upward and downward part of the path is lost from view with the ordinary microscope which sees approximately in a single plane; with a stereoscopic binocular the real nature of the path is evident. If the constant relation of the body of the organism to the axis of the spiral is likewise overlooked, a peculiarly false conception of the movements of these organisms is obtained, which seems to be somewhat widespread. This is the conception that the organism swerves as it swims, first toward one side, then toward the other.

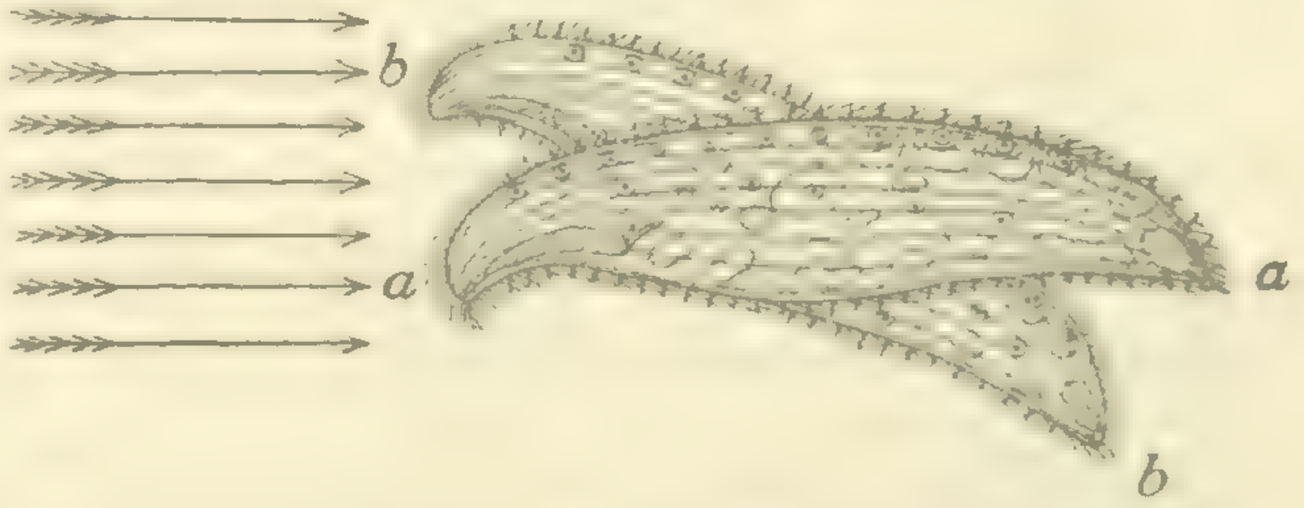

FIG. 5.—Diagram to illustrate supposed oscillation of an unsymmetrical organism when oriented by lines of force (represented by the arrows).

For example, Loxodes or Paramecium, according to this view, would swerve first toward the aboral side, then toward the oral side. This supposed movement has even been given a high theoretical significance, as being the natural result of the orientation of an unsymmetrical organism by lines of force, such as rays of light, or the path of diffusing ions. Thus, in Fig. 5, in the position *a*–*a*, in which the axis of the organism is parallel with the lines of force, more lines of force impinge on the convex side of the organism; hence the locomotor organs on that side act more (or less) strongly than those on the concave side. As a result of this differential action, the organism swings (supposedly) to the position *b*–*b* (that is, it swings toward the aboral or convex side). Now more lines of force impinge on the concave side; the locomotor organs act more (or less) strongly on this side, and the organism swings again (now toward the oral or concave side) into the position *a*–*a*. This continues, and, combined with the forward motion,

supposedly accounts for the sinuous path of these organisms. It should be clearly stated that the actual movements of these creatures lend no support to this account, but are, on the contrary, quite incompatible with it. The organisms swerve always toward the *same* side, not first to one side, then to the other.

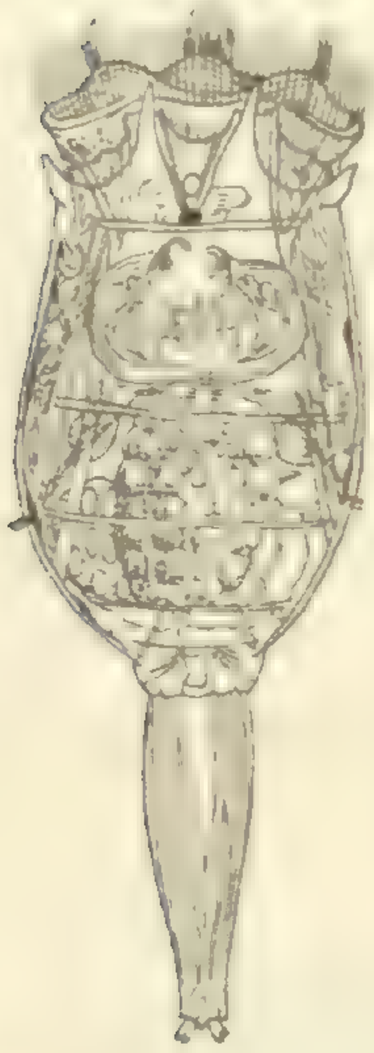

FIG. 6. — Dorsal view of a rotifer (*Brachionus pala*, after Weber) to show the similarity of the two sides.

But it is well known that it is not only unsymmetrical organisms that swim in a spiral, but that the same is true for many bilateral organisms also, — as, for example, the Rotifera. Since the two sides are alike in these animals (see Fig. 6), there is no reason for swerving to the right rather than to the left, and the spiral path calls for some further explanation. The significance of the spiral path in such cases is clearly seen when the movements of these animals are carefully studied. When creeping on the bottom or the surface film, there is no rotation. Here the only possibilities of deviation from the straight line are either to the right or to the left, and since the two sides are alike there is no reason for swerving in either direction. But the dorsal and ventral sides are not alike (see Fig. 7), and in swimming freely through the water the animal might err by turning toward the dorsal or toward the ventral side, or in any intermediate direction. As a matter of fact, careful observation shows that most rotifers do swerve toward the *dorsal side* as they swim freely through the water. This tendency seems traceable to the fact that the rotifers are primitively creepers on the bottom, and most of them still retain this habit. In order to rise from the bottom into the free water, the animal must necessarily move toward the dorsal side (as in Fig. 7). The cilia which bring about the free-

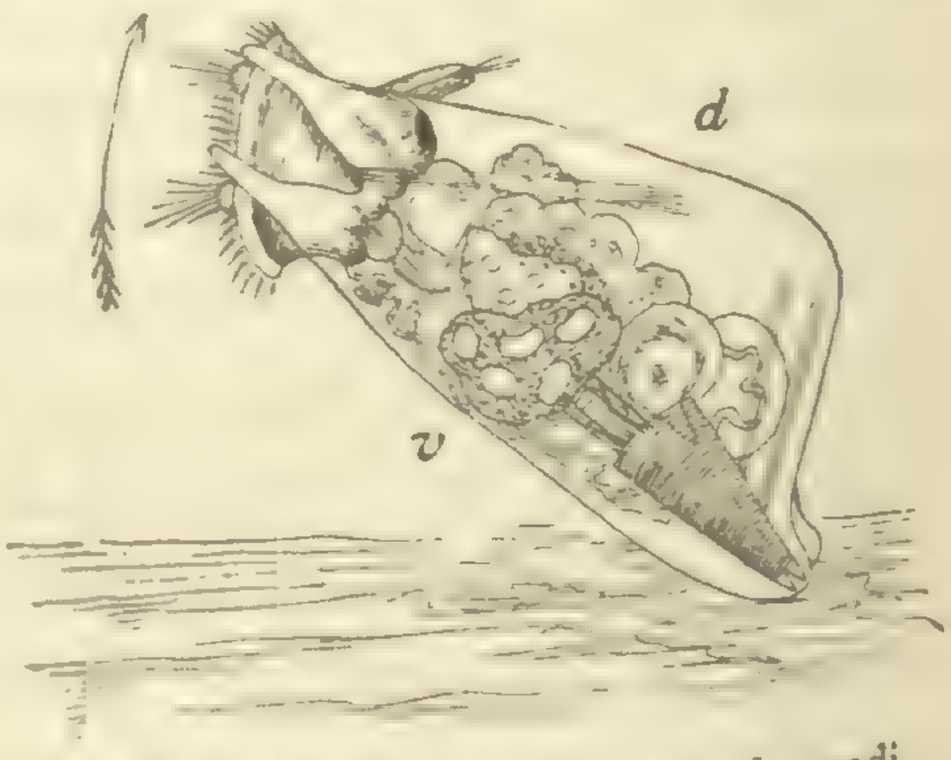

FIG. 7. — Rotifer (*Brachionus pala*, modified from Hudson and Gosse), side view, showing the turning toward the dorsal side when rising from the bottom. *d*, dorsal side; *v*, ventral side.

swimming movement seem to have this tendency, to strike so as to turn the animal toward the dorsal side, strongly ingrained. Many of these animals cannot rise from the bottom so long as the dorsal side is down. In such a case the dorsal side of the head repeatedly strikes the bottom until, by revolving on the long axis, the dorsal side is turned toward the free water; the animal then swerves off the bottom in that direction. Some

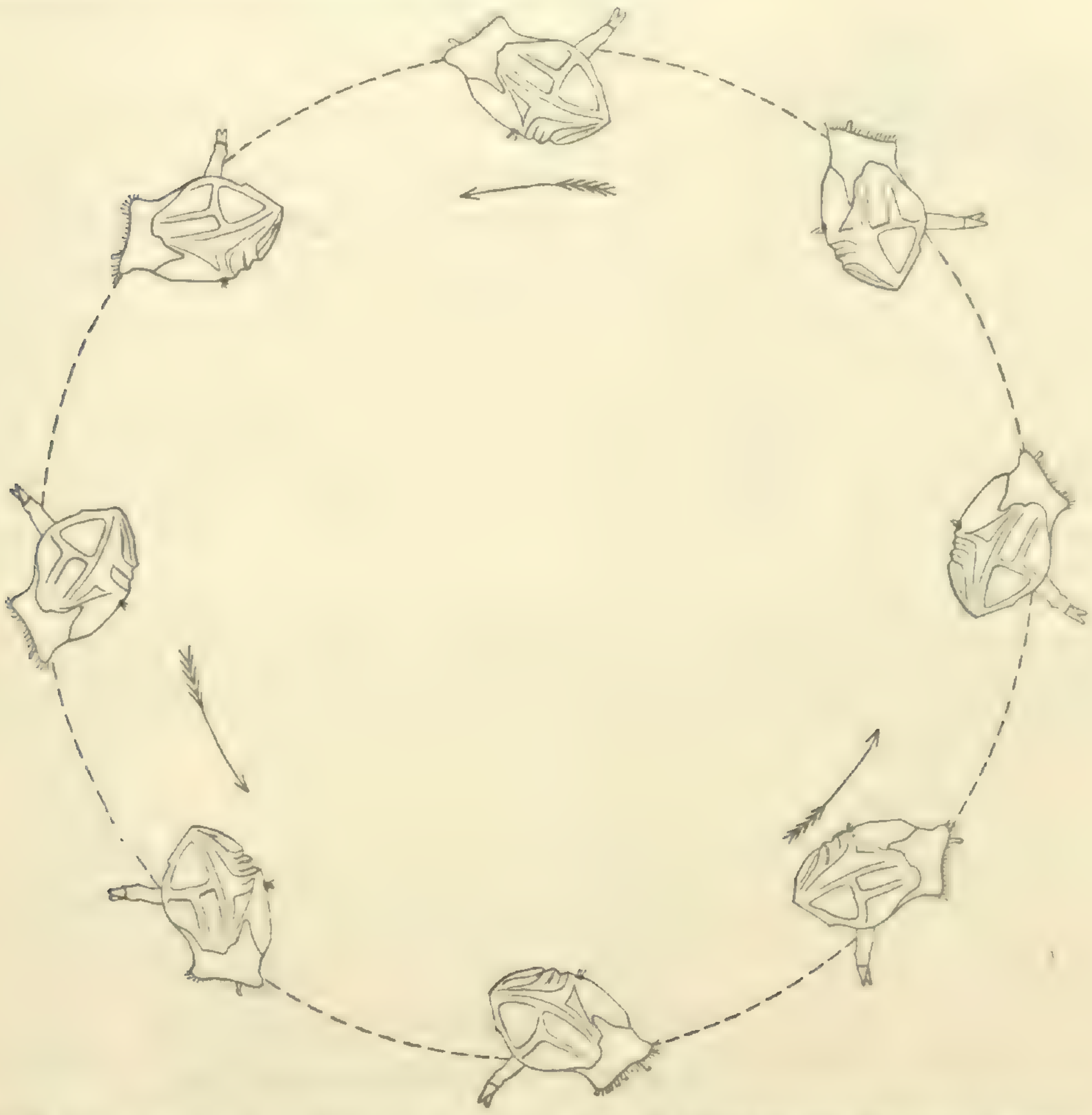

FIG. 8. — Diagram showing course followed by Plœsoma when swimming without revolving on the long axis. The animal continually swerves toward the dorsal side, hence follows a circular path.

of the rotifers, if they attempt to swim freely through the water without revolving on the long axis, turn backward somersaults, over and over, describing thus small circles. I have seen Plœsoma thus describe circles (Fig. 8) for considerable periods. But as soon as the animal begins at the same time to revolve on the long axis, without otherwise changing its movement, the effect is striking. The purposeless circular movement

FIG. 9. — Diagram showing the course of Plœsoma as soon as it begins to revolve on the long axis (*a* and *c* are higher and lower, respectively, than *b* and *d*, which lie in the same plane). This spiral course, with the dorsal side to the outside of the spiral, is characteristic for many Rotifera.

(Fig. 8) becomes at once a well-ordered progression in a spiral path (Fig. 9). No one who has seen this sudden change from random circles to a path having all the essential qualities of a straight line can fail to appreciate the biological significance of the rotation on the long axis in compensating the tendency to swerve in a given direction.

This tendency to swerve toward the dorsal side seems present in the majority of the free-swimming Rotifera, and is compensated almost universally by the revolution on the long axis, causing the resulting path to be a spiral with the dorsal side directed toward the outside of the spiral (Fig. 9). All rotifers observed by the writer revolve to the right, and no reversal of the direction of revolution was ever seen.

In some of these primitively bilateral animals this spiral method of swimming has resulted in the production of an unsymmetrical form analogous to that of the infusoria. In the small aberrant family of Rattulidæ this adaptation to a spiral movement is most striking. *Rattulus tigris*, for example, has a twisted body, forming actually a segment of a spiral, and there is in addition a high spiral ridge on one side. This ridge begins behind the middle, near the mid-dorsal line, and passes forward, at the same time curving over to the right side. The animal swims in a spiral of which this ridge and its own twisted body form a part.

Asymmetry appears sporadically in many different groups of the Rotifera; possibly it may in every case be brought into relation with the spiral method of swimming.

The Rotifera are a group of organisms excessively varied in form and movements, furnishing a most excellent opportunity for studies on the interdependence of structure and function. Some species (*e.g.*, certain species of Diaschiza) have the body so curved ventrally that the tendency to turn toward the dorsal side is more than compensated, and the animal tends instead to curve continually toward the ventral side. This tendency is of course likewise corrected by the revolution on the axis of progression, the path taking here the form of a spiral with the ventral surface to the outside. Some few rotifers have become so modified that revolution on the long axis has become unnecessary for keeping a straight course. Thus *Euchlanis triquetra* (a view of which from the rear is shown in Fig. 10) has developed three great keels, one dorsal and two lateral, which tend to prevent swerving in any direction; so this animal frequently swims freely for long stretches without revolving, while the closely related *Euchlanis oropha* (having no keels) almost continually revolves as it passes through the water.

FIG. 10.—View of a swimming *Euchlanis triquetra* from behind (after Ehrenberg) to show the three keels.

FIG. 11.—One of the Gastrotricha (*Chætonotus macrochætus*, after Zelinka), showing the position of the cilia (*a*) on the ventral side.

Revolution on the long axis, with the resulting spiral path, is common also in many other animals. In the Gastrotricha (*e.g.*, Chætonotus, Fig. 11) the locomotor organs (cilia) are confined to a strip on the ventral side, (*a*) which necessarily results in giving the organism a tendency to turn toward the dorsal side. The revolution on the long axis is therefore of great importance for producing an effective forward movement.

Revolution on the long axis is also to be observed in many rhabdocœls. It is indeed one of the commonest features in the locomotion of small fresh-water organisms, and doubtless occurs in salt-water forms in the same way.

On the whole, then, it is clear that revolution on the long axis, with the resulting spiral path, is of high biological significance. Only through this device are many organisms enabled to follow a course which is practically a straight one; without such revolution many creatures merely describe small circles, making no progress whatever. By means of this revolution on the long axis, any organism, no matter how misshapen and irregular, may follow a course which is, in effect, equivalent to a straight line. The simple device of revolving in the axis of progression is surprisingly effective, in that it compensates with absolute precision for any tendency or combination of tendencies to deviate from a straight course in any direction whatsoever.

ANN ARBOR, MICH., January 5, 1901.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XIV. The Hydromedusæ — Part II.

CHAS. W. HARGITT.

The Campanulariæ (Calyptoblastea).

The Campanulariæ are distinctively colonial Hydromedusæ, many of them most exquisitely beautiful and graceful forms. In size they vary from very minute forms barely visible to the unaided eye, to forms like Halecium, measuring from twelve to twenty inches or more in height. The hydranths are provided with specialized receptacles, hydrothecæ, into which they are capable of more or less complete retraction. Gonophores are produced by budding, and are provided with specialized receptacles, gonangia, similar in morphological features to the hydrothecæ. The gonophores may be liberated as free medusæ, or may remain fixed as medusoids, the sexual products maturing within the gonangium and later escaping as free larvæ or planulæ. When free, the medusæ are known as Leptomedusæ, characterized generally by a low, flat bell, marginal sense organs usually of the vesiculate type, with the gonads usually borne along the underside of the radial canals.

A classification of the Campanularidæ is almost, if not quite, impossible without the presence of the gonosome, which in many genera is the most distinctive differentiating feature. In the following synopsis this feature will be in constant requisition, and where it is absent in specimens the student is admonished as to the doubtful character of purely morphological determinations.

SYNOPSIS OF FAMILIES.

CAMPANULARIDÆ. Hydrothecæ campanulate, terminal, borne on distinct pedicels ; gonophores fixed or free-swimming. Hydranths with large and somewhat trumpet-shaped hypostome.

LAFŒIDÆ. Hydrothecæ deep tubular, sessile or pedicellate ; hydranths with conical hypostome.

HALECIDÆ. Hydrothecæ usually reduced to shallow, disk-like receptacles (hydrophores). Hydranths with conical hypostome. Gonophores as imperfectly developed medusoids.

SERTULARIDÆ. Hydrothecæ borne in double rows, adnate to hydrocaulus. Gonophores sessile.

PLUMULARIDÆ. Hydrothecæ arranged in single row only on side of hydrocaulus.

CAMPANULARIDÆ.

Synopsis of the Genera.

CLYTIA. Stems simple or rarely branched. Hydrothecæ deeply bell-shaped, with toothed margins, borne on long pedicels. Gonangia producing free medusæ having four marginal tentacles.

OBELIA. Stems regularly branched, hydrothecæ bell-shaped, with entire margins. Gonangia borne on stems and branches and producing free medusæ having numerous marginal tentacles.

CAMPANULARIA. Stems simple or branched. Hydrothecæ campanulate, with margins entire or variously toothed. Gonangia, medusæ as mere sporosacs, within which the sexual products develop and escape as free planulæ.

GONOTHYRÆA. Stems branching ; hydrothecæ campanulate and with toothed margins. Gonangia producing well-developed medusoids, which, while often furnished with tentacles and capable of protruding beyond the orifice of the gonangium, never become free, thus exhibiting an interesting intermediate stage between the first two genera and Campanularia.

Clytia Lamx. (in part).

Generic characters : Stem usually simple, attached by creeping hydrorhiza. Hydrothecæ devoid of operculum. Gonangia produced from stem or hydrorhiza and borne on pedicels which are usually beautifully annulated. Gonosome. Medusæ deeply bell-shaped and with four marginal tentacles when first liberated. Otocysts eight, two in each interradius. Both these and the tentacles increase in number with the age of the medusa.

1, *C. bicophora* Ag. (Fig. 16).

Trophosome: Colony rarely attaining a height of more than an inch, composed of simple or sparingly branched stems. Hydrothecæ deeply bell-shaped and numerously and sharply toothed, borne on elongate pedicels which have terminal annulations.

Gonosome: Gonangia symmetrically annulated and usually arising from the hydrorhiza. Medusæ when first liberated of hemispherical shape and with four tentacles and eight otocysts.

Habitat: Usually on fucus, occasionally on shells or other hydroids.

Fig. 16.—*Clytia bicophora* Ag.
(After Agassiz.)

2, *C. cylindrica* Ag.

(*Cont. Nat. Hist. U. S.*, vol. iv.)

Trophosome: Stems simple, hydrothecæ tubular, small, deep, with sharply pointed teeth. Pedicels short, with proximal and distal annulations.

Gonosome: Gonangia oblong, somewhat flattened, devoid of annulation, producing free medusæ.

Habitat: Similar to last species.

3, *C. grayi* Nutting.[1]

Trophosome: Stem simple or irregularly branched, strongly annulated except in middle branch. Hydrothecæ very large, cylindrical. Numerous marginal teeth, rounded and not deeply cut. Hydranth with about twenty tentacles.

Gonosome: Gonangia oblong, conspicuously and regularly annulated, attached to creeping rootstocks.

Habitat: Growing on living worm tubes, composed of sand. Dredged from depth of 31 fathoms. The largest Clytia yet found in American waters.

Obelia Peron and Leseur.

Generic characters: Colony often plant-like, of whitish color, attached by creeping hydrorhiza; hydrothecæ campanulate and devoid of operculum. Gonangia borne on stems and branches, producing free medusæ characterized by numerous marginal tentacles, four radial canals, and eight otocysts symmetrically disposed on the inner margin of each interradial quadrant.

[1] Condensed from Professor Nutting's original description.

1, *O. commisuralis* McCr. (FIG. 17).

Trophosome: Colony long, slender, profusely branching, branches spreading in graceful curves on each side of the main stem, which may attain a height of six to eight inches.

Gonosome: Gonangia elongate, slender, obconical, opening by terminal, circular orifice arising from the base of the cone on a short conical neck. Medusæ when first liberated have sixteen marginal tentacles, four radial canals, beneath which later the gonads develop.

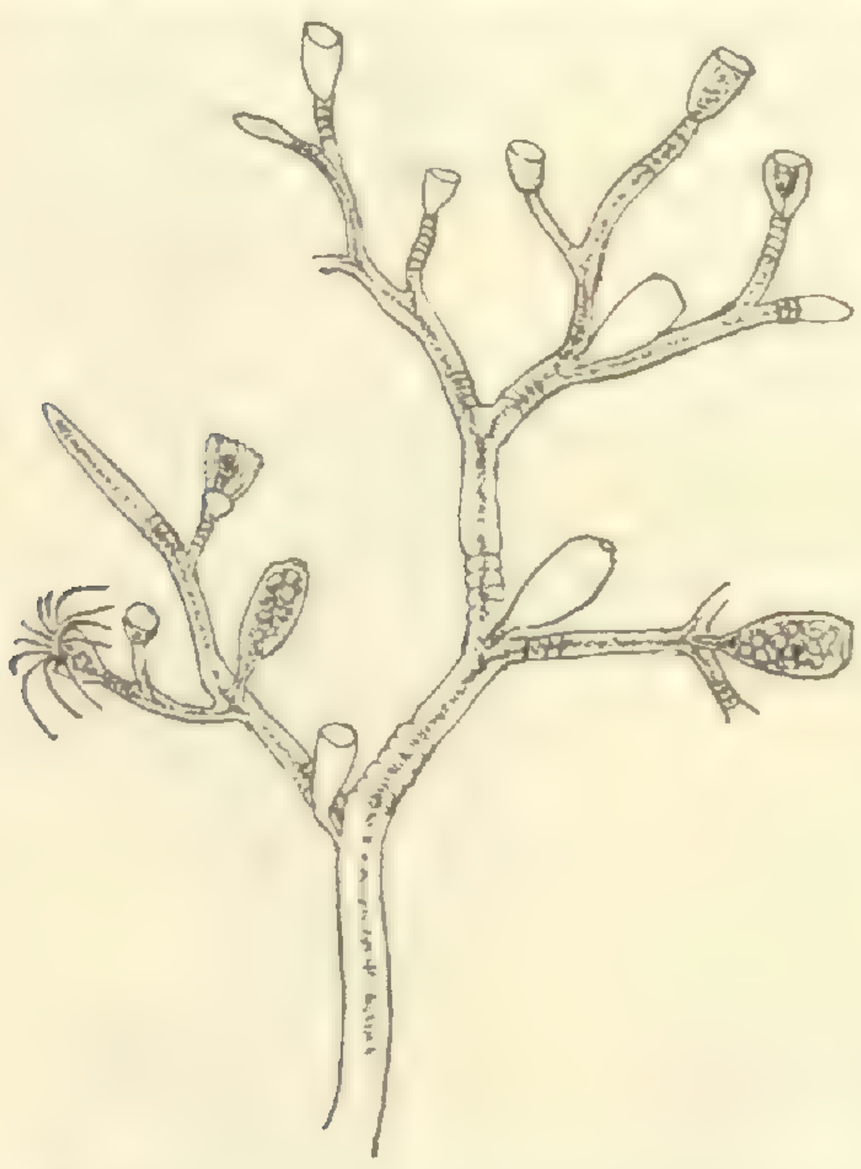

FIG. 17.—*Obelia commisuralis* McCr. (After Agassiz.)

2, *O. dichotoma* Linn.

Trophosome: Colony rather small, stem slender, irregularly branched, annulated just distal to origin of branches, the latter annulated at irregular intervals. Hydrothecæ large, deeply campanulate, borne on annulated pedicels.

Gonosome: Gonangia axillary, slender and smooth, somewhat obconical, and similar to those of former species. Medusæ with sixteen tentacles, manubrium somewhat trumpet-shaped.

3, *O. flabellata* Hincks.

Trophosome: Stem filiform, alternately branching, giving the stem a somewhat zigzag character. Both stem and branches variously annulated. Hydrothecæ alternate, short, widely open and with entire margins, borne on tapering annulated pedicels.

Gonosome: Gonangia axillary, obovate, with tubular orifice. Medusæ?

4, *O. geniculata* Linn. (FIG. 18).

Trophosome: Colony inconspicuous, rarely attaining a height of more than an inch. Stem somewhat zigzag in form as in former species, but apparently jointed at each bend. Hydrothecæ obconical, rather short, with plain orifice, borne on short annulated pedicels.

Gonosome: Gonangia axillary, urceolate, borne on short pedicels. Medusæ discoid, with twenty-four tentacles when liberated, greatly increasing in number with age.

Habitat: Common along Massachusetts and north Atlantic coast, on Fucus and Laminaria.

5, *O. gelatinosa* Pallas.

Trophosome: Stems fascicled, rising from a fibrous hydrorhiza to a height of eight to ten inches. Branches opposite in pairs, which alternate with each other in vertical arrangement, presenting a verticillate appearance. Hydrothecæ small, borne on long slender, ringed pedicels, and having notched margins of a somewhat castellated form.

Gonosome: Gonangia axillary, ovate, flattened at distal end and provided with raised orifice. Medusæ with sixteen tentacles when liberated from gonangium.

6, *O. longissima.*

7, *O. bicuspidata.*

8, *O. bidentata.*

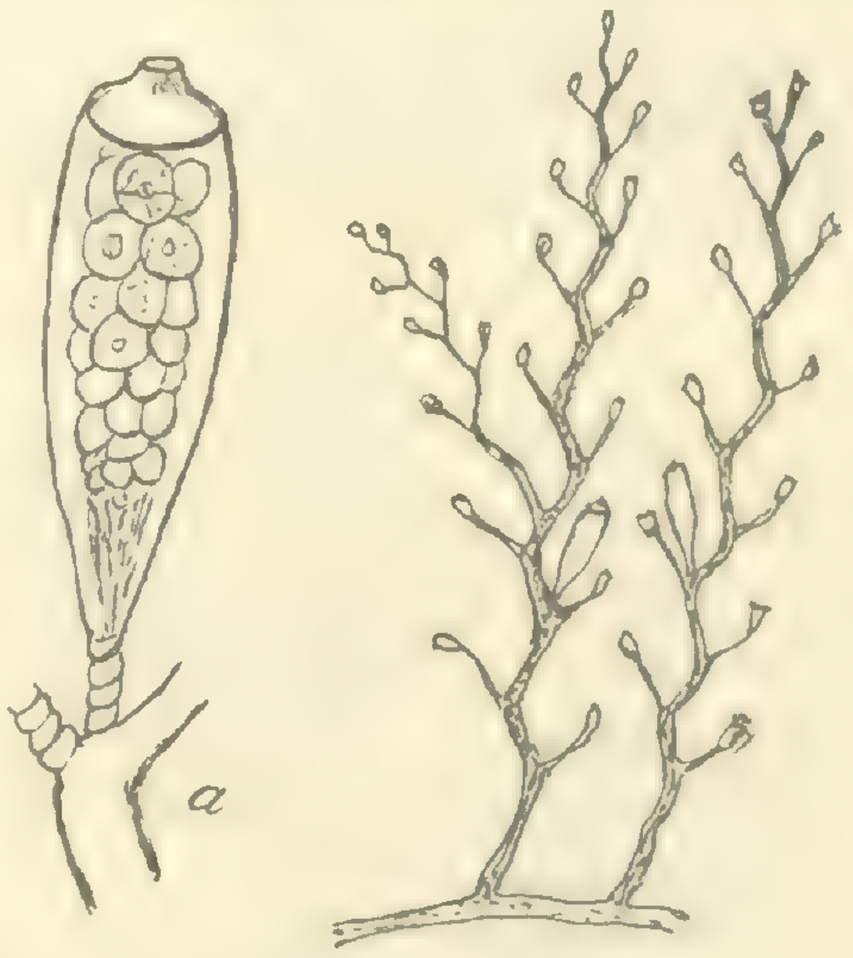

FIG. 18.—*Obelia geniculata* Linn. *a*, gonangium of same enlarged.

Species 6, 7, 8 are listed from Professor Nutting's records, but have not been taken by the present writer.

Campanularia Lamx. (in part).

The generic characters are fairly explicit under the synopsis of genera.

1, *C. caliculata* Hincks.

(Clytia poterium Ag.)

Trophosome: Stem simple, of variable length, bearing a single hydrotheca which is campanulate, with entire margin, and with a thick wall forming a sort of diaphragm within the lower part, thus giving the appearance of a double-walled cup.

Gonosome: Gonangia irregular, oval in shape, with undulating outline and with wide circular aperture. Medusoids extremely degenerate. Larvæ escaping as free-swimming planulæ.

Habitat: Massachusetts Bay, Nahant, Nova Scotia, on seaweed, etc.

2, *C. hincksii* Alder.

Trophosome: Stems rather long, mostly simple: hydrothecæ large, deep, almost tubular, the margins scalloped with castellated teeth.

Gonosome: Gonangia ovate, elongate, somewhat narrowed toward extremity, irregularly annulated throughout, borne on short, smooth pedicels. Medusoids degenerate; ova forming a central mass within the capsule.

3, *C. volubilis* Linn.

Trophosome: Stems usually simple, long and somewhat twisted. Hydrothecæ deep and sub-tubular, margins with shallow undulations.

Gonosome: Gonangia flask-shaped, smooth, with an elongate neck borne on short pedicels.

Habitat: Frequently found growing upon other hydroids, usually in deep water. Gulf of St. Lawrence, Massachusetts coast, etc.

4, *C. neglecta* Alder.

Trophosome: Stems regularly branched, delicate, filiform, branches pinnate, both stem and branches more or less annulated. Hydrothecæ narrow, deep, borne on annulated pedicels and with marginal teeth bimucronate.

Gonosome: Gonangia axillary or on short pedicels which are annulated, pear-shaped.

The colony is very minute and inconspicuous.

5, *C. verticillata* Linn.

Trophosome: Colony composed of erect, fascicled stems, irregularly branched. Hydrothecæ bell-shaped, rather large, deep, with from ten to twelve teeth about the margins, borne on annulated pedicels.

Gonosome: Gonangia flask-shaped, smooth, borne on short pedicels and terminating in narrow orifice.

FIG. 19.—*Campanularia amphora* Ag. (After Agassiz.)

6, *C. amphora* Ag. (FIG. 19).

Trophosome: Colony resembling in general aspects that of *Obelia commisuralis*, attaining in some cases a height of four to six inches. Hydrothecæ campanulate, with entire margins, borne on annulated pedicels.

Gonosome: Female gonangia elongate, somewhat obconical, borne on short annulated pedicels and opening by a terminal aperture. Male gonangia elongate, oval or spindle-shaped. Medusoids more or less degenerate, never becoming free; the male, according to Agassiz, attaining a higher stage of development than the female. The embryo escapes from the gonangium as a free-swimming planula.

7, *C. angulata* Hincks (Fig. 20).

Trophosome: Stems slender, slightly branched, strongly geniculate or undulate in habit. Hydrothecæ alternate, campanulate, with entire margins, borne on long slender pedicels which arise at each flexure of the stem or branch.

Gonosome: Gonangia somewhat ovate, obscurely wrinkled, and terminated by a broad aperture. Colony small, varying from ½ to ¾ inch.

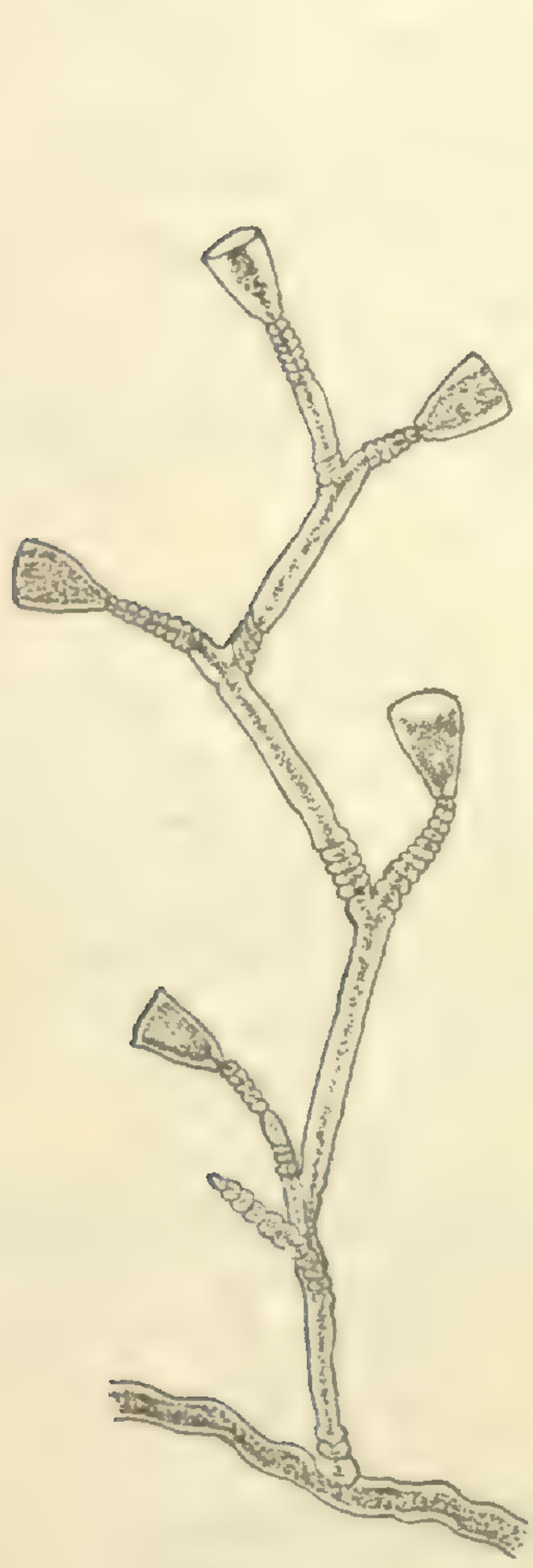

Fig. 20.

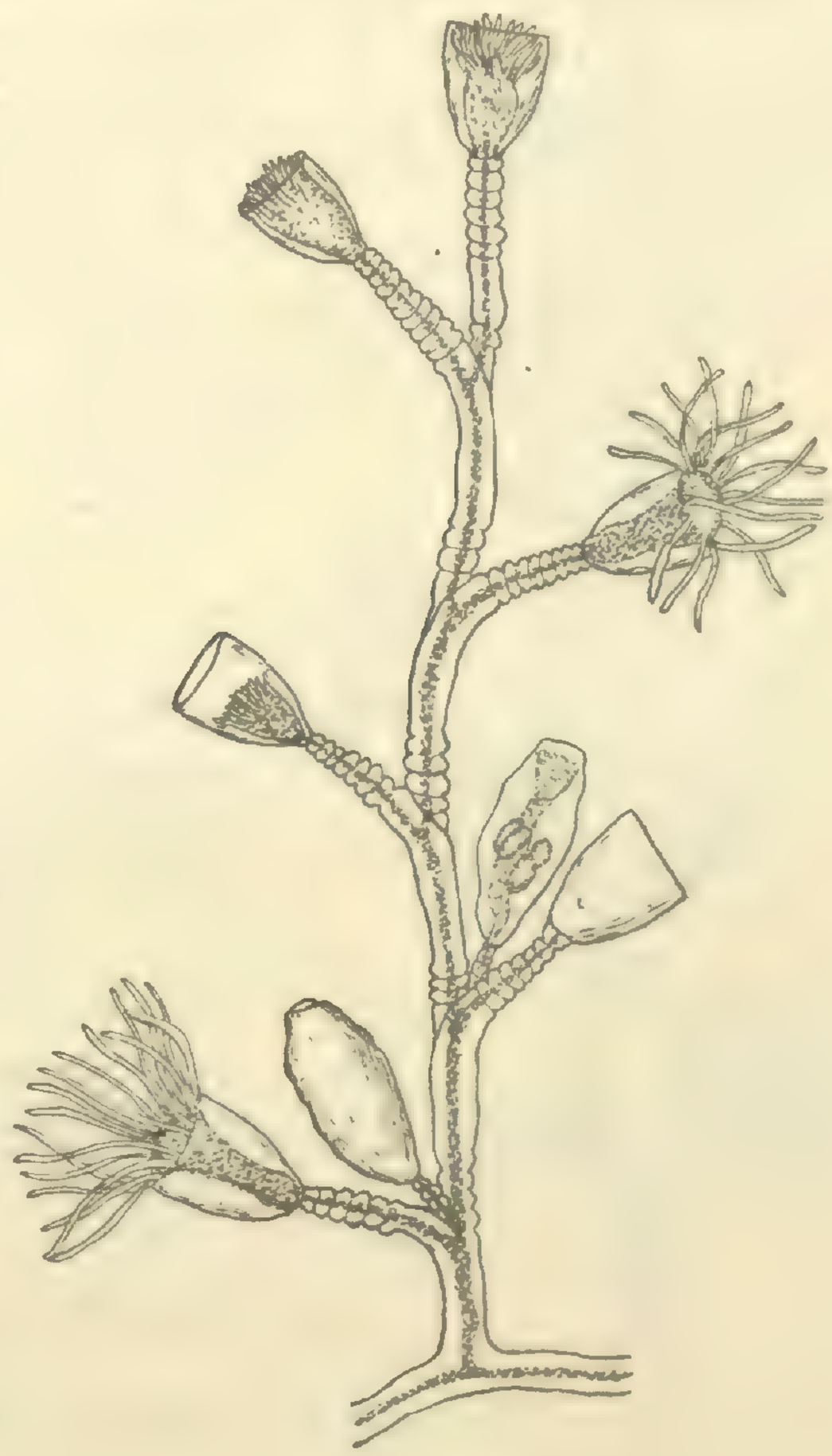

Fig. 21.

Fig. 20. — *Campanularia angulata* Hincks. (After Hincks.)
Fig. 21. — *Campanularia flexuosa* Hincks. (After Hincks.)

8, *C. flexuosa* Hincks (Fig. 21).

Trophosome: Stem flexuous, irregularly branched, annulated near the base and above the origin of branches. Hydrothecæ large, subcampanulate with plain margins, borne on long annulated pedicels.

Gonosome: Gonangia axillary, large, elongate, smooth, and borne on short annulated pedicels. Male gonangia sensibly smaller.

Professor Nutting has recorded the following species of which I have no data, and which therefore are merely noted.

C. minuta; *C. Edwardsii* Nutting; *C. calceolifera.*

Gonothyræa Allman.

1, *G. lovéni* Allman (FIG. 22).

Trophosome: Stems erect, somewhat flexuous, irregularly branched, and with annulations above each branch. Hydrothecæ deeply bell-shaped and with toothed margins, borne on short annulated pedicels.

Gonosome: Gonangia borne on short annulated pedicels, axillary, broadly obconical in outline.

Habitat: On fucus and other algæ, rocks, etc. Cold Spring Harbor, Woods Holl, etc.

FIG. 22.—*Gonothyræa loveni* Allman. (After Hincks.)

2, *G. hyalina* Hincks.

Trophosome: Colony elongate, clustered, profusely branched, with flexuous stems giving off branches at each bend, "Branches erect, very tender and hyaline, sometimes of great length and much ramified." Hydrothecæ elongate, of delicate texture, with numerous marginal teeth and borne on annulated pedicels.

Gonosome: Gonangia oval, axillary, borne on annulated pedicels.

Habitat: On various hydroids, Tubularia, Halecium, etc. (Hincks).

3, *G. tenuis* Clark.

Noted from Nutting's list.

LAFŒIDÆ.

This family has been variously modified of late and by some replaced entirely. In the present synopsis I have chosen to follow in general the classification of Hincks, though recognizing its doubtful reliability in some respects.

Lafœa Lamx.

Stems simple or fascicled, attached by filiform hydrorhiza. Hydrothecæ tubular, with or without operculum. Gonangia oblong, often forming encrusting masses about the stem.

1, *L. dumosa* Flem. (Fig. 23).

Trophosome: Stem creeping, sometimes erect and fascicled; hydrothecæ tubular, margins devoid of teeth or operculum, usually sessile.

Gonosome: (?)

2, *L. calcarata* A. Ag. (Fig. 24).

Trophosome: Stems creeping, simple; hydrothecæ tubular, sessile.

Gonosome: Gonangia large, elongate, obovate or oblong, somewhat resembling those of certain campanularians. Medusæ large, transparent, with

Fig. 23.

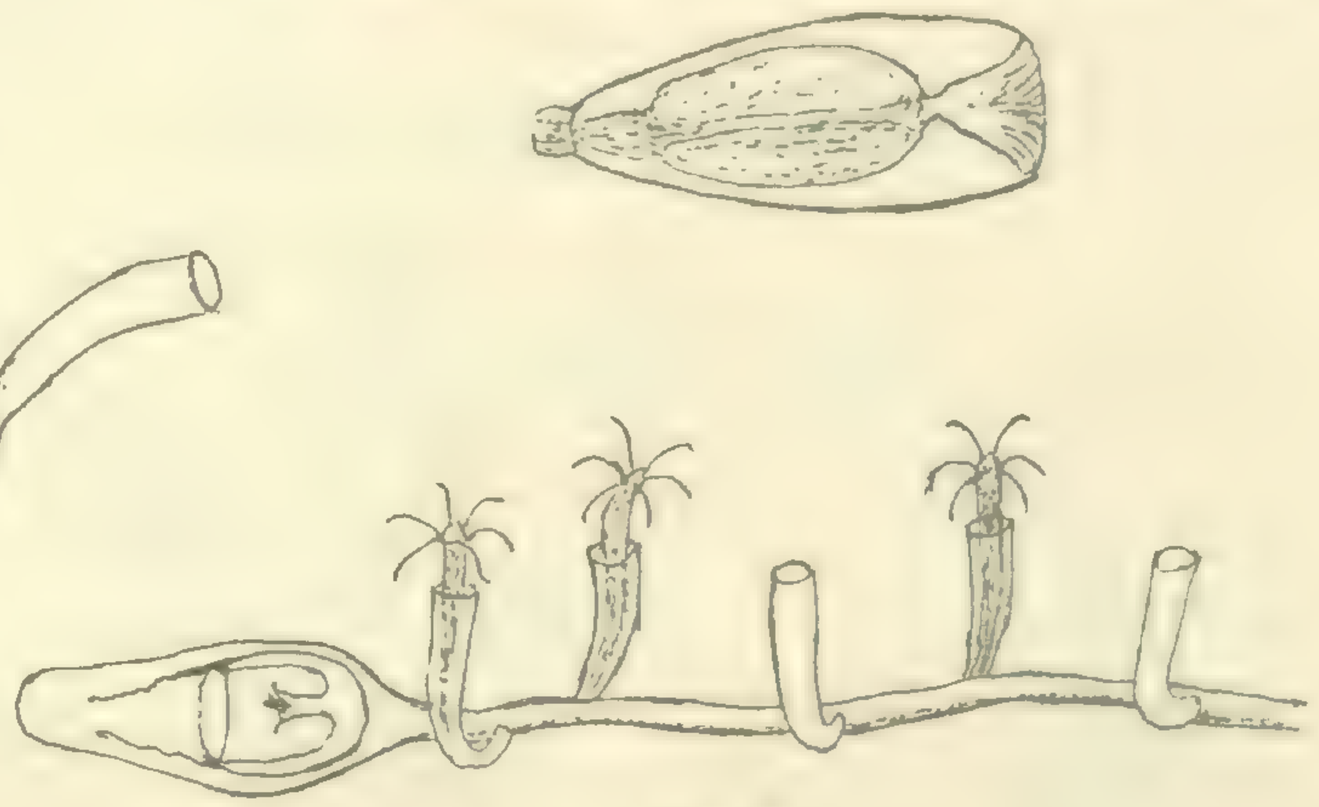

Fig. 24.

Fig. 23.—*Lafœa dumosa* Flem. (After Hincks.)
Fig. 24.—*Lafœa calcarata* A. Ag. (Adapted from A. Agassiz.)

gonads suspended in folds beneath the radial canals; marginal tentacles numerous in mature specimens, only two when first set free.

Habitat: Usually parasitic upon sertularian hydroids.

3, *L. pygmæa* Alder.

Trophosome: Stem creeping; hydrothecæ minute, tubular, elongate, borne on very short annulated pedicels.

Gonosome: (?)

Habitat: Parasitic on various hydroids.

Halecidæ.

Of this family a single genus comes within the range of this synopsis: namely, the type genus, Halecium (Oken), the characters of which may be summarized as follows:

Trophosome: Colony more or less branched, attached by a creeping hydrorhiza. Hydrothecæ often shallow and disk-like, or funnel-shaped (hydrophores). In many species with double or triple margins due to

subsequent secretions as the hydranth grows, leaving the old hydrophore. In many cases the everted rim has on its inner margin a circle of small bright dots which are rather characteristic of the genus. Hydranths imperfectly retractile, elongate, and with conical hypostome.

Gonosome: Gonangia of varying aspects, showing distinctive differences between male and female and affording easy means of distinguishing the sexes. Medusoids imperfectly developed, never free.

1, *H. halecinum* Linn. (FIG. 25).

Trophosome: Colony erect, rather rigid, subflabellate in form. Hydrothecæ alternate, somewhat tubular in form, and with everted rims.

Gonosome: Gonangia borne in a series on the upper side of the branches; those of the male elongate, slender, somewhat spindle-shaped, tapering below

FIG. 25.—*Halecium halecinum* Linn. *a*, male; *b*, female gonangia of same (enlarged). (After Hincks.)

to their attachment by very short, slightly ringed pedicels. Female gonangia somewhat oblong, broader toward the distal end, and with tubular aperture nearer one margin.

2, *H. beanii* Johnston.

Trophosome: Colony of delicate, graceful form, somewhat dendritic, attaining a height of about two inches. Hydrothecæ with everted rims.

Gonosome: Gonangia arising from near the base of hydrothecæ; male, elongate oval; female, somewhat curved, with the aperture situated near the middle of the upper side.

3, *H. tenellum* Hincks.

Trophosome: Colony minute, extremely delicate; stems slender, often strongly annulated, branching irregularly. Hydrothecæ funnel-shaped and with everted margins.

Gonosome: Gonangia ovate, pedicellate.

4, *H. muricatum* Ell. and Sol.

Trophosome: Colony stout, dendritic, profusely branched, and with joint-like divisions, alternately from below which the hydrothecæ arise.

Gonosome: Gonangia ovate, borne on short pedicels, roughly marked with linear ridges of spinous processes.

Eastport, Me. (Verrill).

SERTULARIDÆ.

Synopsis of Genera.

SERTULARIA. Colony plant-like, stems more or less branching, jointed, attached by creeping hydrorhiza. Hydrothecæ in double rows, strictly opposite, usually devoid of operculum. Gonangia with plain margins.

SERTULARELLA. Colony resembling somewhat the former. Hydrothecæ in double rows, but distinctly alternate, with toothed margins and with an operculum composed of several pieces. Gonangia strongly annulated throughout, slightly dissimilar in the two sexes.

DIPHASIA. Colony more or less branching, stem jointed, hydrothecæ opposite, a pair to each internode and often with a valve-like operculum. Gonangia scattered, differing in shape in the two sexes, those of female large, often divided into segments above, male smaller and with central tubular aperture.

THUIARIA. Stem somewhat plant-like, jointed; hydrothecæ in double series sub-opposite, but deeply immersed in the substance of stem and branches.

HYDRALLMANIA. Stems flexuous or somewhat spirally inclined. Hydrothecæ alternate, placed on front of branches, and curved alternately to right and left.

Sertularia Linn.

Generic characters given above.

1, *S. pumila* Linn. (FIG. 26).

Trophosome: Stems straight or slightly curved, simple or branched: branches opposite; both stem and branches divided into short internodes, each bearing a pair of hydrothecæ, the latter opposite, tubular, and somewhat contracted toward the aperture, which faces outward and is more or less cleft or notched.

Gonosome : Gonangia more or less oval, sessile, with marginal rim. Male gonangia somewhat more slender, and regular in outline.

Habitat : One of our commonest sertularians, found attached to fucus, etc., between tide marks and in tide pools.

2, *S. cornicina* McCr.

Trophosome : Colony very small, composed chiefly of unbranched stems, which rarely attain a height of more than ½ inch. Hydrothecæ appearing as lateral emarginations with slightly divergent apertures. Hydranths slender, with about sixteen tentacles.

Gonosome : Gonangia?

The above description is condensed and modified from that of McCrady (*Proc. Elliott Soc.*, Vol. I, p. 204).

FIG. 26.—*Sertularia pumila* Linn. (After Agassiz.)

3, *S. argentea* Ell. and Sol.

Trophosome : Colony of bushy and slightly wavy stems, perisarc dark and horny; branching, alternate, and somewhat dichotomous. Hydrothecæ short, urn-shaped, tapering toward the free and divergent aperture, which is small and oblique.

Gonosome : Gonangia broad, obovate, tapering toward the base; aperture circular, and usually with two divergent spines.

Habitat : Usually from deeper waters, growing on shells, stones, etc., sometimes found near tide marks. Recorded from various points along the New England coast.

4, *S. cupressina* Linn.

Trophosome : Colony slender, elongated. Stems rather stout and straight, alternately branched and dichotomously sub-branching. Hydrothecæ tubular, transparent, somewhat alternate, and adherent throughout most of their length, slightly divergent toward the aperture, which is wide and bilabiate.

Gonosome : Gonangia elongate, tapering toward base, and with prominent spine at each side of the aperture, which is slightly raised and central.

Habitat : Less abundant than the former species, though with similar distribution.

Sertularella Gray.

Generic characters given in above synopsis.

1, *S. rugosa* Linn.

Trophosome: Colony small, simple, or sparingly and irregularly branched; stems annulated. Hydrothecæ crowded, strongly annulated transversely, and with four marginal teeth.

Gonosome: Gonangia large, ovate, strongly annulated, and with a four-toothed aperture.

2, *S. gayi* Lamx.

Trophosome: Stems erect, with alternate branches, somewhat obliquely jointed. Hydrothecæ somewhat urn-shaped, one to each internode, usually wrinkled, and with narrower, divergent, four-toothed aperture.

Gonosome: Gonangia elongate, ovate, tapering toward the small, two-toothed aperture. Usually strongly annulated in upper portion, the lower smooth.

3, *S. tricuspidata.*

Trophosome: Stems slender,

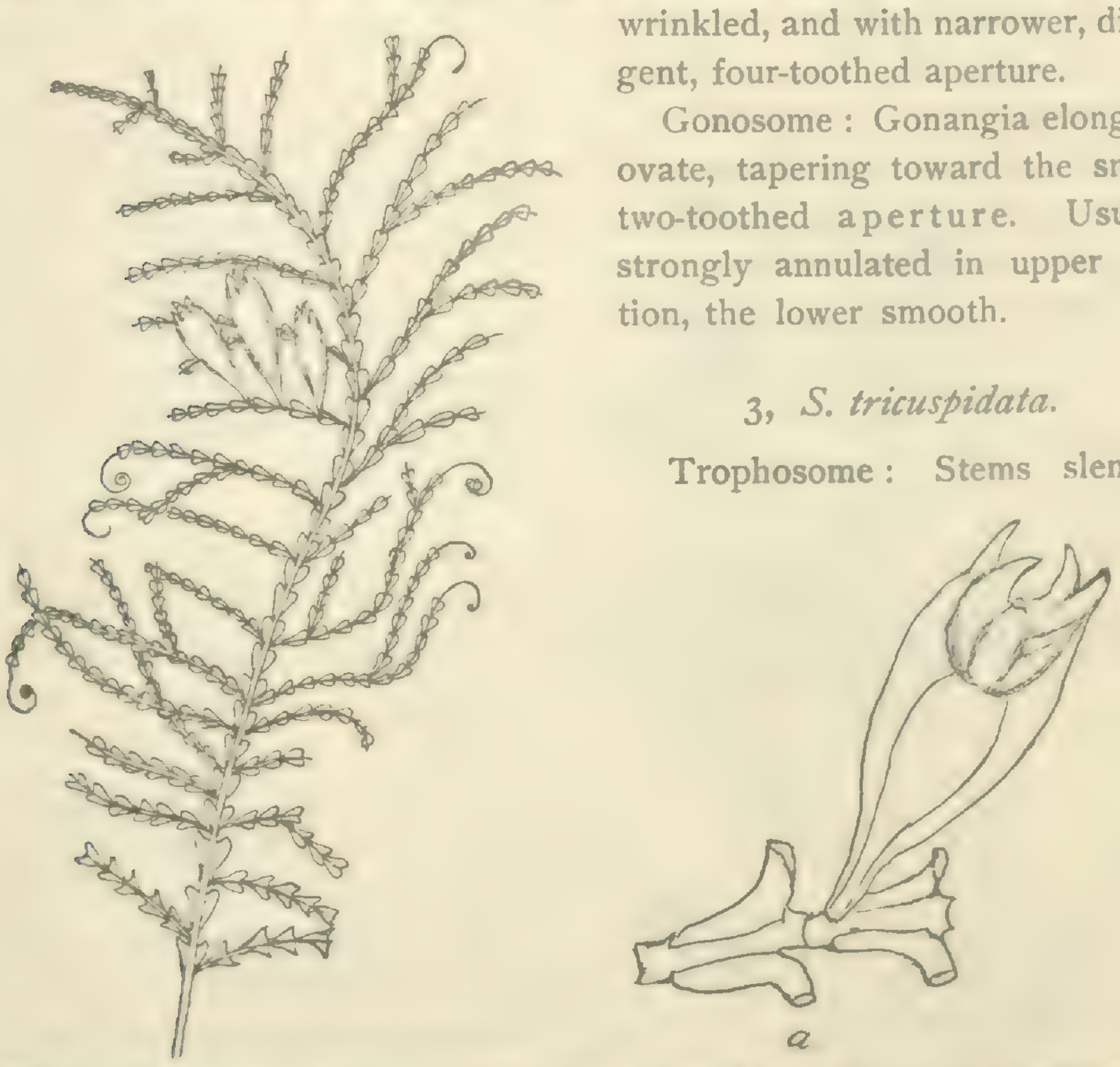

FIG. 27.—*Diphasia fallax* Johnst. (After Hincks.) *a*, ♀ gonangium of same (enlarged).

alternately branched, often bipinnate near the ends. Hydrothecæ cylindrical, smooth, slightly everted, with a three-toothed orifice.

Gonosome: Gonangia large, with strongly transverse ridges and with a plain, funnel-shaped opening.

Diphasia Ag.

1, *D. fallax* Johnston (FIG. 27).

Trophosome: Stems thick, sparingly branched, branches alternate, often terminating in tendril-like bodies. Hydrothecæ short, tubular, with upper part slightly divergent, and with wide, smooth orifice.

Gonosome : Gonangia differ in the two sexes. Male elongate, slender, tapering toward base and expanding toward orifice, which bears four stout spines. Female gonangium oval, deeply cleft above into four leaf-like segments, larger than male.

2, *D. rosacea* Linn.

Trophosome : Stems slender and delicate, branches alternate and with internodes constricted at the base. Hydrothecæ long, tubular, with upper portion free and divergent toward the aperture, which is oblique and entire.

FIG. 28.—*Hydrallmania falcata* Linn.
(After Hincks.)

Gonosome : Gonangia slightly different in the sexes; female pear-shaped, elongate, borne on short pedicels and marked with eight longitudinal ridges, each terminating above in a spinous process. Male somewhat curved toward base, with similar longitudinal ridges terminating in spinous teeth about the slender tubular orifice.

Thuiaria Flem.

A single species of this genus comes within the present synopsis.

Thuiaria thuja Flem.

Trophosome : Stem and branches rather rigid, somewhat zigzag in shape, and annulated near the base. Perisarc black or very dark in color. Hydrothecæ smooth, ovate at base and tapering toward the distal end.

Gonosome : Gonangia smooth, pyriform, and with circular slightly emarginate aperture.

Hydrallmania Hincks.

Hydrallmania falcata Linn. (FIGS. 28, 29).

(Sertularia falcata.)

Trophosome : Stems flexuous, slender, sometimes spirally inclined. Branches alternate, regularly pinnate and plume-like, arising just above

each joint. Hydrothecæ tubular, closely appressed, arranged in rows along the pinnæ, and with plain oblique aperture.

Gonosome: Gonangia ovate, tapering toward the base, and with a tubular orifice.

Habitat: Shells, stones, etc., generally distributed from Grand Manan, Massachusetts Bay, and southward.

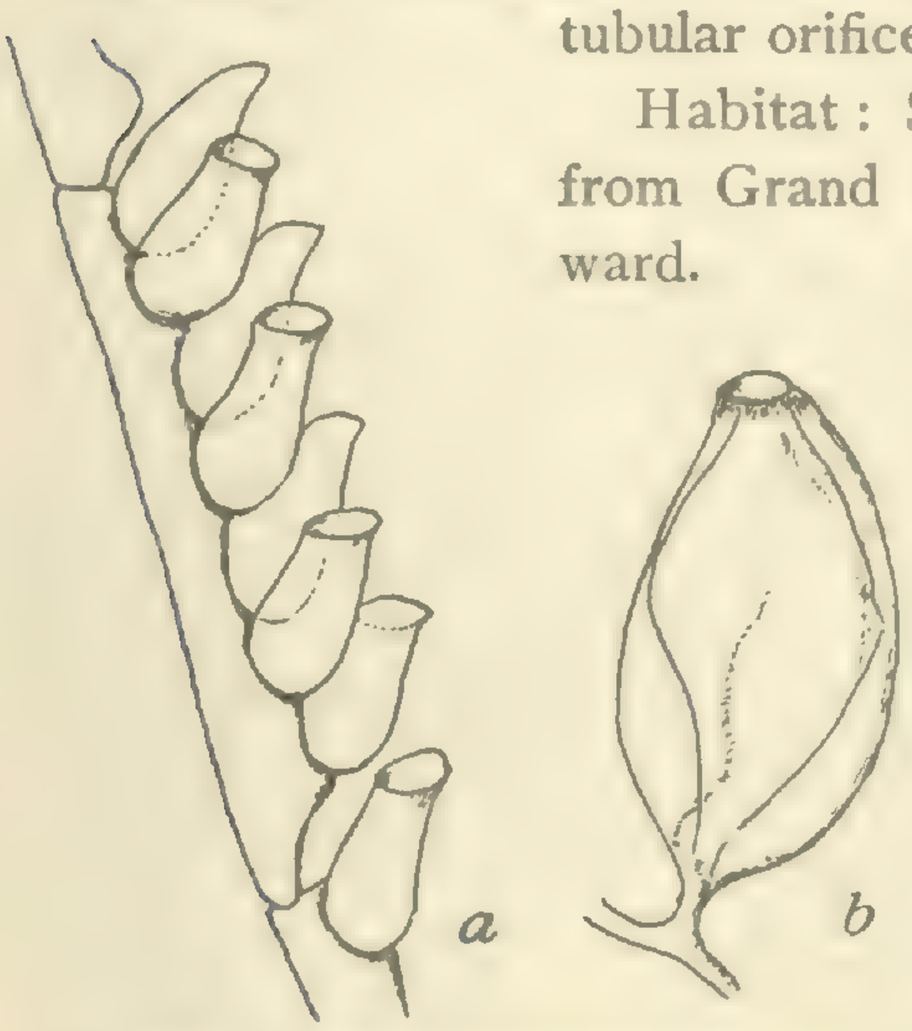

FIG. 29.—*Hydrallmania falcata* Linn.
a, hydrothecæ; *b*, gonangium.

PLUMULARIDÆ.

Synopsis of genera. Modified and condensed from Nutting's Monograph of the Plumularidæ.

ANTENNULARIA. Colony more or less arbuscular, stem simple or branching, jointed, attached by massive hydrorhiza. Branching somewhat verticillate or scattered; hydrothecæ cup-shaped; nematophores trumpet-shaped. Gonangia borne in axils of branches, unilateral.

MONASTÆCHAS. Colony dichotomously branched, stem not fascicled, hydrocladia arising from upper sides of branches, otherwise resembling Plumularia, from which it differs in the entire absence of cauline hydrothecæ. Gonangia oval in shape and with terminal aperture.

SCHIZOTRICHA. Colony branching, branches pinnately arranged, hydrocladia often forked. Gonangia borne on stem or hydrocladia.

CLADOCARPUS. Stem simple or fascicled. Nematophores not trumpet-shaped, definitely fixed to hydrothecæ or branches. Gonangia borne on stem or hydrocladia.

Antennularia Linn.

1, *Antennularia antennina* Linn. (FIG. 30).

Trophosome: Colony growing in dense clusters of upright stems, often eight to ten inches high, stems simple or sparingly branched, obscurely jointed, each internode bearing a cluster of hydrocladia. Hydrothecæ small, cup-shaped, and with slightly everted margins.

Gonosome: Gonangia ovate, borne singly in axils of hydrocladia. Aperture subterminal.

FIG. 30.—*Antennularia antennina* Linn. Portion of stem and hydrocladia (enlarged). (After Nutting.)

2, *A. americana* Nutting.

Similar to former, but usually from deeper water and apparently of exceedingly variable character.

3, *A. rugosa* Nutting.

Trophosome: Colony unbranched, attaining a height of six inches. Hydrocladia in verticils of six or eight, borne on stout processes of the stem and with proximal ends reinforced on the lower sides by a thickening of the perisarc. Internodes long and irregular, further subdivided by numerous irregularly disposed septal thickenings, which resemble joints, giving the appearance of many internodes, where in reality there is but one. Hydrothecæ small, short, cylindrical, and supported below by a thickening of the internode.

Monastæchas quadridens McCr.

Trophosome: Colony subflabellate in form, dichotomously branched. attaining a height of about six inches. Stem not fascicled, with indistinct internodes and branching at irregular intervals, those bearing hydrocladia being divided into long internodes, each of which bears a hydrocladium at its distal upper side. Hydrothecæ large, campanulate.

Gonosome: Gonangia sac-like, borne on short processes below hydrothecæ, and each protected by a pair of nematophores.

Habitat: Various stations along the North Atlantic coast, and from Marthas Vineyard southward.

Schizotricha Allman.

Hydrocladia pinnately disposed, often branching once or more. Two species come within the range of this synopsis.

1, *S. tenella* Verrill.

Trophosome: Colony branched dichotomously, attaining a height of about two inches. Stems clustered or fascicled, divided into alternately longer and shorter internodes, the latter bearing each a hydrotheca and a hydrocladium. Hydrocladium slender, often branched, proximal internodes short, and without hydrothecæ, which are subcylindrical.

Gonosome: Gonangia of curved shape, tapering at base and gradually enlarged toward the distal end, somewhat resembling cornucopiæ.

Habitat: Gay Head, Vineyard Sound, New Haven, Greenport. R. I., Woods Holl, Vineyard Haven.

2, *S. gracillama* Sars. (Fig. 31).

Trophosome : Stem sparingly branched, having a height of about two inches and somewhat fascicled. Branches divided into regular internodes, each of which bears a hydrocladium on a short, stout process near its distal end. Hydrocladia alternate, branching dichotomously twice or more beyond its proximal internode. Hydrothecæ small, cup-shaped.

Gonosome : Gonangia borne in pairs on the stems in the axils of the hydrocladia, and also at the forks of the latter, cylindrical in shape, tapering at proximal ends, sessile.

Habitat : Shallower waters, New England coast.

Fig. 31.

Fig. 32.

Fig. 31.—*Schizotricha gracillima* Sars. Branched hydrocladium (enlarged). (After Nutting.)

Fig. 32.—*Cladocarpus flexilis* Verrill. Portion of hydrocladium (enlarged). (After Nutting.)

Cladocarpus Allman.

Stem simple or fascicled. Hydrothecæ deep and with smooth margins or with lateral sinuations, and with one or two anterior teeth. A single species comes within the range of this synopsis.

C. flexilis Verrill (Fig. 32).

Trophosome : Colony long, slender, sparsely branching, stem not fascicled, attaining a height of about nine inches. Hydrocladia distinct, slightly sinuous, divided into rather slender internodes, each with a number of septal ridges back of hydrothecæ, which are deep, tubular, nearly straight, and with a single anterior tooth at the aperture.

Gonosome : Gonangia numerous, borne on stem and bases of hydrocladia, oblong-ovate, with latero-terminal orifice.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Human Spines.[1] — The paper is, in the words of the author, "a description of forty-five anomalous human spines in the Warren Museum," and of a number of special parts of the spinal column from the same collection ; it is also a discussion of the causes of the spinal variations.

The author describes five classes of spinal anomalies, namely :

1. Spines in which the number of præsacrals is normal, but in which there is an irregularity at the junction of the thorax and loins, or at the junction of the thorax and neck.

2. Spines in which the 26th is the *v. fulcralis*, but in which the 25th is not quite separated from it.

3. Spines in which there are more than 24 perfectly free præsacrals, the extra one being thoracic, or lumbar, or there being two extra præsacrals, one thoracic and one lumbar, the latter sacralized on one side, the 27th being the *fulcralis*.

4. Spines in which one or more præsacral vertebræ are imperfectly developed, one or more vertebræ being fused, the atlas being fused with the occiput, or the 24th being more or less sacralized.

5. Spines in which there is a præsacral too few : a vertebra being wanting in the loins, in the back, there being 12 pairs of ribs, the first pair being cervical and perfect on one side, the 24th being in all the groups the *fulcralis*.

There are further described cervical, rudimentary first thoracic, bicipital and tricipital ribs ; fusion of atlas and occiput, of atlas and axis, axis and third cervical vertebra ; a suppression of a cervical and an extra half vertebra.

The main facts brought out by the paper are (1) a lack of relation between the condition of the spine at one end of the thorax and that at the other, and (2) the frequency of "concomitant" variations on one or both sides of the spine.

[1] *Dwight, Thomas.* Description of the Human Spine, showing Numerical Variation, in the Warren Museum of the Harvard Medical School. *Memoirs of the Boston Society of Natural History*, vol. v, No. 7 (Boston, 1901), pp. 237–312, with figures.

(1) "If the undeveloped end of the 1st thoracic rib is a step towards the future, it would be reasonable to expect in the same spine a corresponding advance below the thorax. Conversely, if there is an archaic condition below the thorax, there should be an analogous condition above it. While there are cases that fulfill these conditions, they are quite lost in the multitude which do not, and which even present contradictory conditions at the opposite ends of the spine, being retrogressive at one end and progressive at the other."

These facts are in contradiction to Rosenberg's theory.

(2) The author points to the cases where "we see a tendency sometimes for the whole thorax to move forward (upward?) by cervical ribs associated with absence of the last thoracic ones or with their existence in a rudimentary condition." "We also see cases in which, when the cervical rib on one side is distinctly larger than its fellow, the last rib on that side is either correspondingly smaller than its fellow, or even replaced by a pretty typical transverse process." These *concomitant variations* "may extend even further, so as to include the sacralization of one side of the last lumbar, or even the absorption of one side of the atlas into the occiput."

The causes of the variation: The author confesses his inability to show the original cause of the phenomenon. "It is clear, however, that the vertebræ at the junction of regions are particularly variable, and it seems hard to doubt that errors of segmentation may occur. The original error having occurred, there seems to be a tendency in the organism to reproduce the type as nearly as may be under the changed conditions; to make as normal a series of regions as circumstances will permit; and this tendency manifests itself to some extent independently in the two halves of the spine." For this tendency the author adopted the old and rather unsatisfactory theory of "the vital principle."

Professor Dwight closes his interesting work with the following additional deductions:

1. Variations occur in two ways: (1) by irregular development of the costal elements at and near the ends of the regions of the spine, and (2) by irregular segmentation through which there are more or fewer vertebræ than normal.

2. Variations of both kinds are variations around a mean. It is not impossible that some of them may be reversive; that any are progressive is mere assertion.

3. Assuming the correctness of Rosenberg's studies in ontogenesis,

his view may account for some of the variations, but even in these cases something more is needed to explain the concomitant changes.

4. Variation of the costal elements at one end of a region is often associated with variation of an opposite nature of those at the other end. Several regions may be involved, and the two sides may vary independently.

5. Variations, which separately seem either reversive or progressive, generally lose that appearance when the whole spine is considered.

6. After the occurrence of the original error in development there is a tendency for the spine to assume as nearly as possible its normal disposition and proportions. This, as do also concomitant variations and indeed all development, implies a "vital principle."

These deductions of the author naturally invite discussion; but it will be of advantage if this be deferred until the material bearing on the points in question is still more abundant and the observations extended. Conclusions of this nature apply not only to the part under consideration but largely to the whole skeleton.

A. H.

Notes.— Four "Cruciform Structures near Mitla" are described by Mr. M. H. Saville in Vol. XIII of the *Bulletin of the American Museum of Natural History*. After a scholarly summary of the history of previous explorations at Mitla the author confines his attention to the cruciform burial chambers which are unique in form and surpass all other tombs in Mexico or Central America in size and in beauty of stone work.

"A Bilateral Division of the Parietal Bone in a Chimpanzee; with a special Reference to the Oblique Sutures in the Parietal," is the subject of a paper by Dr. Aleš Hrdlička, appearing in the same volume. It contains a detailed description of the skull of an adult male chimpanzee, with a discussion of the important problems connected with the abnormal parietal sutures. An oblique suture, the author believes, can be attributed to only three possible causes, as follows: an early fracture, a persistence of the original separation between the two centers from which the bone is developed, and a coexistent difference between their relative positions; the existence of a supernumerary third center of ossification. The brochure is illustrated by six outline drawings.

In the *Report of the Museums Association of the United Kingdom* for 1898 Mr. Harlan I. Smith advises an "ethnological arrangement

of archæological material," and suggests a classification under thirteen main divisions of such material, with a view to illustrating ancient tribal life and ethnology. This method would make the specimens aid in solving problems and would find a use for many now discarded as unworthy of attention.

The *Report* for 1899 contains a paper by Mr. Smith upon "the preservation of local archæological evidences," showing the danger of their obliteration by man and nature, and the necessity of systematic explorations in this country as well as in foreign lands. More accurate and complete records should be kept by means of indices and catalogues. Mr. Smith makes suggestions for local work under the auspices of state universities and historical societies.

An interesting example of "psycho-physical study" is given in Mr. Arthur MacDonald's "Emile Zola," reprinted from *The Open Court*, August, 1898. This study was made by a number of French specialists, and the result published with the approval of the subject. Among the characteristics investigated are antecedents, mental evolution, physical peculiarities, the nervous system, ideas, sentiments, and will. This empirical method is employed in order that we may come to have somatology of the living as well as of the dead, and thus gain a knowledge that will be of practical use in ameliorating social conditions.

In the *Bulletin* (Vol. VIII, No. 2) of the French Society of Anthropology, M. Zaborowsky discusses at some length the problems of the racial unity and the place of origin of the Slavs. He concludes that:

1. The Slavs of the North came from the region between the Danube and the Adriatic. They were related to the neighboring inhabitants of the terramare of Emilia. The migrants may have been drawn toward the north by the trade in amber.

2. They passed the Carpathians through the valleys of the Oder and Vistula, following especially the latter to the vicinity of the Baltic, where they developed an independent culture.

3. The Slavs introduced the custom of cremation, until then unknown. They brought metals and glass; iron was used for ornament only.

4. They formed a branch or included the tribes of the Venedes of the Adriatic; the name Venedes dates back in the Baltic region to the fourth century before our era.

5. By their dominant characters they approach the French Keltic type. The southern Slavs are dark and brachycephalic. To the

northward of the Carpathians they encountered a neolithic blond population which they absorbed and in part perpetuated in certain regions.

6. Upon the Oder, the lower Vistula, and along the Baltic coast, where they have pushed back the Finns toward the east, their culture was modified by contact with the Germans from Scandinavia.

F. R.

ZOÖLOGY.

Evermann and Marsh on the Fishes of Porto Rico. — One of the most thoroughly admirable of faunal works is the report on the *Aquatic Resources and Fisheries of Porto Rico*, just published by the United States Fish Commission. The authors are Dr. Barton Warren Evermann and Millard C. Marsh.

In this work are given full descriptions of 291 species, arranged systematically, with analytical keys and numerous figures in the text. A general discussion of the waters and of the geographical features of the island is given by Dr. Evermann, and a chapter on the fish trade and fishing methods by William A. Willcox.

The work is illustrated by 49 colored plates, by C. B. Hudson and A. H. Baldwin. The accuracy and excellence of these plates cannot be too highly praised. Without invidious comparisons we may doubt if any plates of fishes ever published excel in fineness of coloration some of these (as the Nassau Grouper, Plate XII, and the Red Hind, Plate XIII) by Mr. Hudson.

The nomenclature and definitions of groups are taken chiefly from Jordan and Evermann's *Fishes of North America*, and the new species are mostly described in the final appendix to that work.

Those not thus included are the following:

Ophthalmichthys caribbæus, Gill and Smith, San Geronimo.
Lycodontis albimentis, Culebra Island.
Myctoperca bowersi, Culebra.
Scorpæna albifimbria, Culebutas.
Pontinus beanorum, San Juan.
Citharichthys arenaceus, Mayaguez.
Sphagebranchus ophioneus, Mayaguez.
Apogon sellicauda, Culebra Island.
Neomænis megalophthalmus, Puerto Real.
Scorpæna bergi, Mayaguez.
Emblemaria pandionis, Isabel Segunda.
Halieutichthys smithi, Mayaguez.

The name Peprilus is substituted for Rhombus, preoccupied in mollusks. A few other changes in the nomenclature, adopted from Jordan and Evermann, will be found necessary. These may be

briefly noted without statement of the reasons: Sardinia for Clupanodon, which should be restricted to the group in Japan and China, lately named Konosirus; Anchovia for Stolephorus, which was based on a Japanese Spratelloides; Esox (Esocidæ) instead of Lucius; (the type of a Linnæan genus, according to Linnæus," is the best known European or officinal species") ; Syngnathus for Siphostoma, the same rule covering these cases; Bodianus should replace Harpe, the genus called Bodianus by Jordan and Evermann standing as Cephalopholis; Dipterodon should replace Neomænis, if the latter is really distinct from Lutianus; Eupomacentrus is probably not distinct from Pomacentrus; Tropidichthys should replace Canthigaster, the latter a bare definition without species. Probably Carapus must replace Fierasfer. Lepisoma must take the place of Labrisomus, which replaces Gobioclinus. Probably Ichthycallus should be used instead of Iridio.

D. S. J.

Studies of Animal Life.[1] — In this new series of laboratory exercises for use in high schools — the outgrowth of experience in the schools of Chicago — the authors have aimed to make the practical work of elementary zoölogy a study from the view-point of animal life, interpreting structure in the light of activity. While the outlines for the study of the activities of living animals are as extensive as is probably practicable for most schools, by far the greater part of the laboratory work is a study of structure. Students are not expected to dissect, but many points of internal structure are to be demonstrated from permanent preparations.

In the form of its outlines the book is an example of the reaction from the older manuals, — which consisted of description to be verified by the students, — in that it contains numerous questions, along with a minimum of description and guiding information. Some of the questions are of doubtful value in elementary zoölogy, for example: "Why are there no fresh-water echinoderms?" "Is there anything about the life history of man to suggest the metamorphosis of insects?" "What traces of an invertebrate exoskeleton are still present in man?"

In order "to develop the subject of the evolution of life from simple to complex forms," the authors follow the so-called logical order and begin with the Protozoa, because "high-school pupils are not more familiar in any true scientific sense with higher forms." If this

[1] Walter, H. E., Whitney, W., and Lucas, F. C. Boston, Heath & Co., 1900. 106 pp. *Teacher's Book of Suggestions*, with 31 pages.

be true, there is inconsistency in some questions in the first lessons; for example: "Is there evidence that Paramœcia can breathe?" "Has the Amœba a stomach?" Such questions are meaningless unless the pupil has some scientific knowledge of structure and functions in higher forms.

On the whole, the spirit and plan of most of the lessons may be commended. Many teachers will welcome this as a laboratory guide which aims to meet the popular demand for less study of comparative anatomy and more about animal life in secondary education.

M. A. B.

Human Physiology. — Dr. Wm. D. Zoethout's translation of Schenck and Gürber's *Human Physiology*[1] places within reach of the English-reading student one of the best of the shorter German physiologies. The translation is from the second German edition and follows the original closely. After a brief introduction on general physiology, the subject-matter is arranged under three heads — metabolism, the transformation and setting free of energy, and reproduction and development. The treatment is as modern as is consistent with general soundness. Thus we are told that "a solution tastes the more sour the greater the number of hydrogen atoms replaceable by metals contained in the unit of volume," a statement which includes all that is up to date without involving the reader in the dissociation hypothesis. Although the text of the book has been compiled with great conciseness and care, it is to be regretted that the illustrations are so inadequate. Thus the figure showing the general anatomy of the ear as copied from Helmholtz, and the positively inaccurate drawing of the cross-section of the lamina spiralis membranacea are scarcely justifiable. Nor is there good reason why the olfactory epithelium should be illustrated by a figure from Max Schultze, when such work as that done by Retzius, Van Gehuchten, and others is so readily accessible. Such defects, however, are small compared with the merits of the volume, which should be in the hands of every medical student and every teacher of elementary physiology.

P.

Korschelt and Heider's Embryology of Invertebrates. The fourth part of the English edition of Korschelt and Heider's *Ent-*

[1] Schenck, F., and Gürber, A. *Outlines of Human Physiology.* Translated from the second German edition by Wm. D. Zoethout. New York, Henry Holt & Co., 1900. viii + 339 pp.

wicklungsgeschichte der wirbellosen Thiere completes the translation of this monumental work.[1] As in the second and third parts, the translation has been done by Matilda Bernard, and the revision and editing by Martin F. Woodward. The present part gives an account of the embryology of the mollusks, the tunicates, and Amphioxus, and in the groups covered agrees with the third part of the German edition except in the omission of the chapters on the brachiopods and the Bryozoa, which the translators had previously placed in their second part. The third part of the German edition appeared in 1893; the translation, therefore, is unfortunately some seven years late. This has put on the editor the heavy task of supplying the more recently acquired information on the groups under consideration. Mr. Woodward has wisely refrained from rewriting the third portion of the work, and has attempted to bring it up to date by employing footnotes and adding to the literature lists, as in the former part. While this is perhaps the best way out of the difficulty, it does not seem to have been employed very successfully in this last part. As an example, the chapter on Amphioxus may be cited. Our advance in the knowledge of the embryology of this form is indicated in some seven notes, none of which give very extensive information. The appendix to literature for this chapter contains some fifteen new titles. As these presumably cover the period from 1893 to 1900, the list is obviously incomplete. One misses any reference to Lwoff's completed paper on the germ layers (1894), Legros's note on the morphology of the sexual glands (1895), MacBride's note on germ layers (1896), Garbowski's discussion of the mesoderm (1898), Klaatsch's account of the structure and development of the tentacles (1898), Lankester's note on the development of the atrial chamber (1898), and Legros's description of the development of the buccal cavity (1898), contributions which, judging from the composition of the literature lists in the German edition, should have been recorded. Incidentally it may be mentioned that of the names given in this appendix Hamman is substituted for Hammar and the capitalization of MacBride is unsteady. On the whole, the additions made by the editor do not show the high standard of work characteristic of the German original. The presswork, particularly in connection with the illustrations, retains more or less of the muddiness of the earlier parts. Notwithstanding these shortcomings.

[1] Korschelt, E., and Heider, K. *Text-Book of the Embryology of Invertebrates.* vol. iv. Translated by Matilda Bernard, revised and edited by Martin F. Woodward. New York, The Macmillan Company, 1900. xii + 594 pp., 312 figs.

the translation is generally so well done that the work, now that it is completed, cannot but be a boon to the English-reading student.

P.

Heart-Beats in Salpa. — The pulsation of the heart in three species of Mediterranean Salpas has been exhaustively studied by L. S. Schultze.[1] As is well known, the hearts of these animals beat first in one direction and then in the other. A complete set of *adrisceral* or of *abrisceral* beats constitutes a *pulsation series*. The intervals between pulsation series are known as *pauses*. An advisceral pulsation series and its pause, followed by an abvisceral series and its pause, form a *compound heart period*.

The numbers of beats in pulsation series were so extraordinarily variable that a normal number could not be found. The total number of abvisceral beats may be considerably more or less than that of the advisceral beats; thus in one case 247 abvisceral beats corresponded to 100 advisceral beats, and in another 237 abviscerals to 523 adviscerals. The rates of the two sets of beats were, however, very close; thus 100 abvisceral beats were accomplished in 175 seconds, and the same number of adviscerals in 174 seconds. As the water in which the animal was kept lost oxygen, the rate of beating increased; thus an individual's heart, which at the beginning of the experiment beat 100 times in 208 seconds, after six hours beat the same number of times in 148 seconds. Of the three species studied, the two larger ones, *Salpa africana-maxima* and *Cyclosalpa pinnata*, had an average rate of 26 to 30 beats per minute; the smaller, *Salpa democratica-mucronata*, 107 per minute. The pauses between ad- and abvisceral series varied from 1 to 4 or occasionally 5 seconds.

Each heart-beat is a peristaltic wave that sweeps over the heart from one end to the other. Usually a new wave appears at one end before the old one has passed off at the other, and sometimes as many as seven waves may be counted on a heart at once. Krukenberg believed that the two ends of the heart were physiologically very different, and that nicotine and hellebore affected the advisceral pulsations only, the former diminishing, the latter increasing them. Schultze, however, found that these poisons influence the ab- as well as the advisceral pulsations, and thus demonstrated that the ends of the heart were not in this respect dissimilar.

[1] Schultze, L. S. Untersuchungen über den Herzschlag der Salpen. *Jenaische Zeitschr. f. Naturwissenschaften*, Bd. xxxv (1901), pp. 221–328. Taf. IX–XI.

The source of the stimulus for the contraction of the heart muscle was sought for in several ways. An isolated heart was found to be capable of beating regularly in either direction. Stimulation of the animal's brain had no effect on the heart-beat. Removal of the brain reduced the rate, but this was shown to be due to the loss of substance suffered by the animal and not to the removal of the brain. The filling of the heart with blood was shown not to be necessary for its contraction. As small fragments of the heart muscle continued to contract rhythmically, and yet on examination showed no evidence of nerve fibres or of ganglion cells, Schultze concluded that the motor stimulus for the action of the heart muscle must be generated exclusively by the metabolism of that muscle itself.

The alternating action of the heart depends on the capacity of its muscle to transmit the stimulus to contraction directly from fibre to fibre and on the varying rhythm of the two ends of the heart. In moribund individuals both ends of the heart may at times give rise to contraction waves simultaneously. These usually meet near the middle of the heart and neutralize one another. In normal individuals the rhythm at one end is so much more rapid than that at the other that this rhythm asserts itself for the whole heart. When, however, the muscle tissue of the given end becomes somewhat exhausted by continued action and thereby reduces its rate of contraction, the muscle substance of the opposite end, having recovered from the effects of its own previous action, may be able to establish a more rapid rate than its opponent, and thus the center of propagation is transferred to the recuperated end. Hence the quiescence of a given end permits that end to recuperate till its own rhythm can supersede that of the opposing end, and its action gradually exhausts it so that its opponent in turn will be able to gain the ascendency.

P.

Flies as Carriers of Disease. — Dr. L. O. Howard, in a recent paper,[1] has presented the possibilities of the transmission of disease by flies in a particularly striking manner. A large number of flies, representing many species, were bred from human excrement. Those seen visiting the same material were collected. Then collections were made in dining-rooms and pantries, and many sheets of sticky fly-paper examined to see what species commonly occur in

[1] A Contribution to the Study of the Insect Fauna of Human Excrement, *Proc. Wash. Acad. Sci.*, vol. ii (1900), pp. 541–604.

houses. By comparing the two series, those visiting and bred from excrement and those found in houses, it is at once apparent what species are liable to carry disease germs. The results show that practically all of the house flies occasionally breed in or visit human excrement. It is thus possible that almost any house fly may carry the germs of typhoid fever The next step in this process, *viz.*, to find out by experiment whether flies actually carry germs on their tarsi and labellæ, was not investigated.

No less than thirty-six species of flies were reared from excrement, and forty-one other species captured visiting the same material. Among those bred were the common house fly (*Musca domestica*), and the pomace fly (*Drosophila ampelophila*). The latter is an especially dangerous species, as it not only frequents houses, but also occurs on grapes and other fruits exposed on the market.

In the course of the work, many new and interesting observations of purely scientific value were made on the life history of various species. A large amount of the disagreeable work was performed by Mr. F. C. Pratt, and the determination of the flies rests on the authority of Mr. D. W. Coquillett. N. B.

Trematode Fauna of Egypt.[1] — Just as the earlier works of Looss marked a new epoch in the study of the comparative anatomy of the distomes, so the present paper is destined to be the starting point of a movement toward the rational dismemberment of an ancient and honorable genus — Distomum. Not that others have failed to recognize its heterogeneous character, or to attempt its dissolution, but that up to the appearance of the paper under discussion no one has indicated a reasonable way to the end desired. Many authors have recognized groups of forms whose relationship was evident, and yet have failed to give such groups their true position as genera, or have seized upon single and insufficient characters to delimit them. Thus Rudolphi endeavored to employ external features, which in a group of such uniform exterior does not suffice; Dujardin selected a single feature, the character of the alimentary canal, for the major part of his genera, while both Diesing and Monticelli erred in the same direction. To be sure, certain small groups were recognized and set off from the remainder, but the systems proposed have never met general acceptance, probably

[1] Looss, A. Weitere Beiträge zur Kenntniss der Trematoden-Fauna Aegyptens, zugleich ein Versuch einer natürlichen Gliederung des Genus Distomum Retzius, *Zool. Jahrb.*, Abt. Syst., Bd. xii, pp. 521–784, 9 pls.

because of their inadequacy and of the heterogeneous character of the genera so formed. Then even the groups which were best made were taken as subgenera rather than in their true place as genera, and even subfamilies, which Looss is unquestionably the first to recognize in any broad way. This view does not in the least underestimate the admirable work of Braun and Lühe, which has appeared almost synchronously with that of Looss, and which, though dealing with fewer forms, furnishes evidence of the naturalness of the proposed dismemberment by the independent selection of identical groups.

Looss discusses first the law of priority in relation to helminthology, and advocates on cogent grounds the dating of generic names in this field from Rudolphi, "the Linnæus of helminthology." Though much to be desired, his proposal must still be regarded as impracticable in view of the close relation of synonymy in all groups. Looss protests strongly, and, most will admit, rightly too, against the use of conjecture in restoring old generic names and cities from Rudolphi Hemiurus and Echinostoma as recognizable and evidently good genera, with Sphærostoma as unrecognizable and Schisturus which depends upon pure conjecture. The law of priority is based upon the legal presumption that the literature is available everywhere, but a comparison of original specimens is not called for, since they exist, if at all, in a few places at most. The replacement of specific names, already well fixed, by comparison of the originals is hence in violence with the wording of the law; if, however, it is to be carried out, general interests demand the earliest possible revision of all originals, since in this way the least disturbance will be produced. Names of species which do not exist in original specimens and which are not recognizable should be dropped at once so as not to burden the literature further. Looss then refers to the custom of Rudolphi in citing unknown parasites by the name of the host in genitive; *e.g.*, *Distoma meropis*, which should be interpreted as "a distome from Merops," but which, as the author wrote in Latin, has the outward form of a generic and specific combination. Such names are pure *nomina nuda*, since a diagnosis is lacking and were so regarded by the author, since he never used a genitive as a specific name, and since he also never omitted the "R." which is lacking after these, from the new species actually described.

The second section of the paper on the taxonomy of the distomes opens with a discussion of previous efforts in this direction, and of the great disparity in form and structure between Bilharzia,

Apoblema, and other forms. For the diœcious distomes a new family, the Schistosomidæ, is created, and the remainder, constituting many subfamilies, is left in the family Distomidæ. Since, however, the genus Distomum is nonexistent, this ought to have been changed to Fasciolidæ. A similar change is necessary with the name Monostomidæ, but what name shall be used in its place is not now clear.

Looss then gives the following scheme of the classification as emended, in connection with which it should be noted that there are numerous genera whose position even yet is a matter of doubt, and that this is not regarded by the author as in any sense a complete system :

A. Aspidocotylea Mont.
(remains unchanged)
Metastatica Lkt.
B. Malacocotylea Mont.
Family HOLOSTOMIDÆ Brds.
(remains unchanged)
Digenea s. str. Lkt.
Family DISTOMIDÆ Mont. (partim)
Subfamily Amphistominæ Looss (= Family AMPHISTOMIDÆ Mont.)
" Fasciolinæ Lss.
" Omphalometrinæ Lss.
" Opisthorchiinæ Lss.
" Echinostominæ Lss.
" Cœnogoniminæ Lss.
" Philophthalminæ Lss.
" Lepodermatinæ Lss.
" Gorgoderinæ Lss.
" Brachycœliinæ Lss.
" Pleurogenetinæ Lss.
" Cephalogoniminæ Lss.
" Dicrocœliinæ Lss.
" Syncœliinæ Lss.
" Heterolopinæ Lss.
" Urogoniminæ Lss.
Family (inquir.) RHOPALIADÆ[1]
" SCHISTOSOMIDÆ Lss. { Koellikeria Cobbold; Schistosomum Weinland; Bilharziella n.g.
" GASTEROSTOMIDÆ Braun
" DIDYMOZOONIDÆ Mont.
" MONOSTOMIDÆ Mont. } Remain unchanged

[1] According to the recent investigations of Braun (*Zool. Anz.*, Bd. xxiii, p. 27) closely related to the Echinostominæ and consequently not of family rank.

According to Looss the formation of a special genus is warranted when a certain definitely circumscribed complex of characters can be recognized in two forms which also agree in other respects; yet genera may be founded on single forms of evidently isolated structure. While general appearance is of value, yet internal anatomy is the real basis of subdivision, and just this is, in fact, little known, partly at least owing to ignorance regarding the relative importance of characters. Among the most weighty generic characteristics are the copulatory organs which show the following types: (1) No muscular cirrus sac closed proximally and distally about the duct and seminal vesicle, together with the constant, if often weakly developed, prostate which lies (*a*) free in the parenchyme, or (*b*) enclosed in a connective-tissue covering open at both ends; (2) a closed muscular cirrus sac which encloses (*a*) the genital sinus, *i.e.*, the more or less elongated common terminal portion of both male and female ducts, or (*b*) only the end of the male duct. Here again the cirrus sac may enclose (*a*) seminal vesicle, prostate, ejaculatory duct, and protrusible cirrus, or (*b*) only the last three, the vesicle lying in the parenchyme, or (*c*) the prostate also is free, while only the duct and the cirrus are enclosed in the sac. The course of the uterus in the body is also an important generic character, while the size of the eggs is uniform within narrow limits in any genus. Of specific value are the size and form of organs in detail, the extent of the vitellaria, a very constant feature in any species, and similar details.

In the section treating of the characters of the subfamilies and genera one finds a great variety in manner of treatment. Most groups are considered *in extenso* with full-faced headings which claim immediate attention, but there are those which are introduced in the middle of a topic under another heading, or even rarely one finds a new genus thrown in parenthetically which, in the absence of key and index, makes its discovery difficult. Still the work is generally free from such slips, and the absence of a key is attributable to the often repeated assertion of the author that this is a fragment and not a finished system, having for its primary object the demonstration of the existence of natural groups of family and generic rank within the limits of the old genus Distomum Retzius.

From this section, as well as from the fourth and last, which contains a description of the new and little known species that have been studied by the author, it is hopeless to give here anything regarding the wealth of descriptive and comparative matter which is offered. It is not too much to say that no other helminthologist is

the equal of Looss in deciphering, delineating, and comparing the anatomical structure of trematodes, and it would be hard to find, save in his own work, the equal of the nine plates he has given to illustrate this work. Some mention is made of a total of eighty-four genera, including twenty-three old and sixty-one new; of the latter, three are clearly antedated by names proposed by Braun, five correspond to groups named by Lühe in a publication of identical date,[1] and four are provisional. Among the fifty-two species described twenty-four are new. One can only regret that the author did not give an index or table of contents, if debarred from forming a key by the incompleteness of his system. As it is, reference to any section or topic is not an easy matter. It may also be said that in rare instances the author fails to apply the principles he has laid down, without giving any reason for the exception; but some slips are unavoidable in a work of such magnitude, and do not detract from its permanent value. Though Looss disclaims having formed any complete system, his work comes nearer that than any one else has yet reached, and will be the foundation on which such a system is to be built.

H. B. W.

BOTANY.

Primitive Algæ and Flagellata.[2] — In reviewing Dr. Blackman's paper, the writer has not mentioned the authorities for the arrangement given therein, which may be found on reference to the paper itself. The article is of the nature of a review of recent work, and the following is but a condensation of its most important points.

The older arrangement of the Chlorophyceæ, given by Wille in Engler and Prantl's *Pflanzenfamilien*, is largely an artificial one, and consequently subject to changes. Of the three groups named by him, the Siphoneæ, Confervoideæ, and Protococcoideæ, only the first

[1] It appears to me clear that both the intent and the wording of the rules covering the choice in case of synchronous appearance of different names for the same forms call for the preference of the extended discussion over the preliminary notice, certainly in all cases where types are named. Under this interpretation Looss's names stand as against Lühe's, save for Dolichosomum, which is preoccupied, and hence gives way to Ithyogonimus Lühe rather than to Dolichodesmus Looss (*Zool. Anz.*, Bd. xxiii, p. 603) of later date.

[2] Blackman, F. F. The Primitive Algæ and the Flagellata, an Account of Modern Work bearing on the Evolution of the Algæ, *Annals of Botany*, vol. xiv, No. lvi (December, 1900), p. 647.

is a natural one. According to Blackman, the green algæ may be considered to originate from two flagellate forms, Chlamydomonas and Chloramœba. From the first type three divergent lines of ascent go off: one leading to Volvox, including the type of motile cell aggregations, another ending in the so-called unicellular Siphoneæ. The third, by far the largest and most important, is called the Tetrasporine type, including forms of non-motile cell aggregations, the main stem of which leads through the simple filamentous forms to the branched Coleochæte, and finally, it is to be supposed, to the higher plants. The Ulvas are properly placed as a specially developed side branch. The always perplexing Conjugateæ are indicated as forming a possible fourth line of ascent from the Chlamydomonas type.

The green algæ which arise from the second flagellate form, Chloramœba, include Ophiocytium, Conferva, and finally the Botrydium forms. It is considered that the gametes of these have in reality two cilia, not one, as previously believed. They are included under the head of the Confervales (Borzi), a title not coincident with that used by other authors, and, with their flagellate ancestors, form a group called the Heterokontæ.

The Phæophyceæ are derived from a brown flagellate, Chromulina, allied to the green Chloramœba. This is widely different from the older view, which recognized the simplest Ectocarpus type as the most primitive brown form. Phæocystis, a form on the border line between algæ and flagellatæ, is taken as the next step in the direction of plants, and is connected with the recently described undoubted algæ forms, Phæothamnion and Pleurocladia, and thence with the Ectocarpus type. The Piatones constitute a side branch from Chromulina.

The red seaweeds, it is suggested, find their origin in a flagellate form (Rhodomonas), which is said to possess a chromatophore of true Floridian red color.

However much one may or may not agree with the conclusions, the paper is a suggestive one and a valuable review of the status of the subject. The changes suggested regarding the Chlorophyceous algæ seem certainly to be in the right direction, except that the connection of the Botrydium forms and Conferva type is not very apparent. As to the brown algæ the identity of the flagellate ancestor does not seem absolutely certain and convincing. A flagellate ancestor for the red seaweeds is a matter of such doubt that, as the author says, it is no more than a suggestion which he makes. H. M. R.

Spermatozoa of Ferns.[1] — This account considerably extends the hitherto published work of Pfeffer and others, and is a valuable contribution to the knowledge of chemotaxis. Buller has found that in addition to malic acid and certain malates, experimented with by previous authors, other substances also exert a positive chemotactic influence on the spermatozoids of ferns. Various tartrates, oxalates, phosphates, and salts of potassium (all substances to be found in cell sap) have an attractive influence. Pfeffer's negative results with such substances are ascribed in the case of organic salts to the use of too dilute solutions; in inorganic salts to the fact that mixtures (*e.g.*, plant ash) were used. Nevertheless, the opinion of Pfeffer that it is a malate which attracts the spermatozoid to the archegonium in ferns is substantiated, by reason of the high degree of concentration required by other salts. Malic acid and its salts attract spermatozoids about fifty times more strongly than do other substances. That it is not free malic acid which is found in the cell sap of the archegonia seems probable in that Pfeffer determined no acid reaction in the exudation, and from the fact that malic acid alone is decidedly poisonous to the spermatozoids.

The fact that the diethylester of malic acid is indifferent indicates an explanation of the chemotactic influence on the basis of chemical dissociation, since the afore-named substance is undissociated in solution, whereas in malic acid and the malates the negative radicle is free as an ion. But at the same time, while it is shown that other undissociable substances, like cane sugar, grape sugar, etc., do not attract the spermatozoids of ferns, it is known that one at least (*i.e.*, cane sugar) does attract those of the mosses, while several attract certain bacterial forms. This fact is mentioned, but no explanation is attempted, beyond suggesting the possibility that some undissociable substances may be found which do exert a positive chemotactic influence on the spermatozoids of ferns. It is then the case, that while certain substances (*e.g.*, malic acid) may be indifferent in an undissociated form, other substances attract in some cases, although there is no dissociation of the molecule. This would naturally hinder at present the drawing of any general conclusions regarding the relation of chemotaxis and dissociation.

The fact that the spermatozoids of *Gymnogramme mertensii* and

[1] Buller, A. H. R. Contribution to our Knowledge of the Physiology of the Spermatozoa of Ferns, *Annals of Botany*, vol. xiv, No. lvi (December, 1900), p. 543.

other ferns come to rest upon the withdrawal of water from their contents is also considered. The swarm period of the spermatozoids of the above-named fern has been determined to be two hours, — a much longer time than reported in previous cases, — during which period the starch stored up in it disappears. H. M. R.

The Flora of Celebes. — The interest which American botanists are likely to feel in the flora of the Pacific Islands in consequence of our occupation of the Philippines makes Dr. Koorders' report[1] on Minahasa, the northeastern horn of Celebes, of more than passing importance to us. In addition to physiographic and similar data this volume, which forms one of the regular series of Mededeelingen issued from the Botanical Garden at Buitenzorg, gives a critical review of what had previously been written on the flora of Celebes, an annotated catalogue of the spermatophytes and pteridophytes known to occur in the island, descriptions of a number of new species, and full indices to the popular and scientific names of the plants, as well as chapters on the economic uses of many of the species and tabulations of plants yielding the more important useful products. Unfortunately the text is in Dutch, but diagnoses of new species are in Latin, and there are frequent annotations in German. T.

Notes. — The announcement for the Fourteenth Season of the Department of Botany of the Marine Biological Laboratory at Woods Holl has just been issued. The work will commence on July 3 and continue for six weeks. Courses have been provided in Cryptogamic Botany by Dr. Davis and Dr. Moore; in Phanerogamic Botany by Dr. Charles H. Shaw, and in Plant Physiology by Dr. R. H. True. Plant Cytology will be under the direction of Dr. Davis and Mr. Lawson, and in addition to the regular class work provision will also be made for a series of special lectures. Announcements and further information may be obtained from Dr. Bradley M. Davis, University of Chicago.

The *Bulletin de l'Herbier Boissier*, suspended for a time, appears again, under the direction of M. Gustave Beauverd, curator of the herbarium. The first number of the new series, bearing the date December 29, contains papers on African plants by de Wildeman

[1] Koorders, S. H. Verslag eener botanische denstreis door de Minahasa, tevens eerste overzicht der flora van N. O. Celebes, uit een wetenschappelijk en praktisch oogpunt. Batavia, s'Gravenhage, 1898, xxvi + 716 pp., 10 charts and 3 plates. — **Mededeelingen van s' Lands Plantentuin, No. xix.**

and Durand, ferns of the Amazon region by Christ, Brazilian fungi by the Sydows, the vegetation of Cape Magoary, etc., by Huber, an alpine variety of *Stellaria nemorum* by Beauverd, and a valerian new to the flora of Savoy by Briquet.

Papers of botanical interest in the *Proceedings of the American Pharmaceutical Association* for 1900 are the following: Merrill and Schlotterbeck, alkaloids of *Bocconia cordata;* Gordin, alkaloids of *Ceanothus Americanus;* Kebler, notes on jalap roots; Kraemer, assay of drugs by the use of living plants; Schneider, pharmaceutical bacteriology; Stevens, wild-cherry bark and its preparations; Dohme and Engelhardt, *Atropa Belladonna* or *Scopola Carniolica;* Schlotterbeck, *Adlumia cirrhosa.*

Under the title of *Torreya* the Torrey Botanical Club of New York City has begun the issuance of a monthly journal of botanical notes and news, under the editorial management of Dr. M. A. Howe.

The self-pruning of certain trees, a subject apparently first discussed in this country by Trelease, in the *Report of the Wisconsin Experiment Station* for 1884, and again by Bessey in *Science* for 1900, receives interesting treatment by Schaffner and Tyler in the *Ohio Naturalist* for January. Figures are given illustrating the process in Populus and Salix.

The *Bulletin of the Torrey Botanical Club* for December contains systematic papers on fungi by Peck, lichens by Zahlbruckner, mosses by Mrs. Britton, fernworts by Maxon, and Rocky Mountain phanerogams by Rydberg.

Part XXIII of *Pittonia* is largely devoted to Compositæ and Cruciferæ, with a decade of new Gentianaceæ, a discussion of some neglected generic types, and a batch of corrections in nomenclature.

Thalictrum confine is the name proposed in *Rhodora* for December, by Mr. Fernald, for a plant of Ontario and Maine, which in habit suggests small-leaved *T. Fendleri*, and he shows that *T. occidentale* extends eastwards so as to reach New Brunswick and Maine.

The systematic value of tendrils in Lathyrus is discussed by Fritsch in the *Oesterreichische Botanische Zeitschrift* for November.

Dr. Robinson, in *Rhodora* for December, discusses the nomenclature of Agrimonia in New England.

Dr. Holm contributes an article on the anatomy and morphology of *Erigenia bulbosa* to the *American Journal of Science* for January.

Taraxacum in North America is increased by Professor Greene, in *Pittonia* for January 5, by the description of *T. Chamissonis*, *T. rupestre*, *T. ovinum*, *T. lacerum*, *T. dumetorum*, *T. mutilum*, *T. angustifolium*, and *T. ammophilum*, all from the Northwest, British Columbia, or Alaska.

Senecio, as it occurs in New England, is revised by Greenman in *Rhodora* for January.

Monarda fistulosa and its allies are passed in critical review by Fernald in *Rhodora* for January.

Professor Kellerman, in *O. S. U. Naturalist*, No. 2, gives an interesting plate of variations in the foliage of *Smilax glauca*.

Professor Scribner and his assistants publish a series of studies on American grasses as *Bulletin 24* of the Division of Agrostology of the United States Department of Agriculture.

The specific or hybrid character of *Asplenium ebenoides* is discussed by Mr. Maxon in the *Botanical Gazette* for December, and, unlike Professor Underwood, he considers the suggestion of hybridity as too patent to be ignored, though he admits the absence of positive proof of it.

A remarkably lobed form of *Asplenium ebeneum* is described by Mr. Davenport in *Rhodora* for January, under the varietal name Hortonæ.

Weinzirl, in the *Journal of the Cincinnati Society of Natural History* for December 28, publishes an account of the air bacteria of the arid region of New Mexico, which leads him to the conclusion that the rather few species found differ from those yet described from other regions.

A compilation of the North American Phyllostictas, with descriptions of the species published up to August, 1900, by J. B. Ellis and B. M. Everhart, has recently been distributed by the authors, and bears the imprint of G. E. Smith, Vineland, N. J.

A paper on a spot disease of the violet, due to *Alternaria Violæ*, by R. H. Dorsett, forms *Bulletin 23* of the Division of Vegetable Physiology and Pathology of the United States Department of Agriculture.

No. 5 of Mr. C. G. Lloyd's *Mycological Notes* is largely concerned with Collybia, as represented about Cincinnati.

Professor Cheney has published "an historical review of the work done on the flora of the territory now included within the limits of Wisconsin," in the *Pharmaceutical Review* for December and January.

The sixth fascicle of de Wildeman and Durand's "Illustrations de la flore du Congo," in course of publication in the *Annales du Musée du Congo*, of Brussels, bears date of September, 1900.

The concluding part of Vol. II, and the first part of Vol. III, of J. Medley Wood's *Natal Plants* have recently appeared.

Dr. Henry Kraemer, in the *Proceedings of the American Pharmaceutical Association* for 1900, proposes the use of living plants in drug assaying, to test the strength of certain toxic solutions. In a series of experiments, seedlings of *Lupinus albus* and *Pisum sativum* were grown in strychnine nitrate, brucine sulphate, and tincture of nux vomica solutions of different strengths. The growth of the radicles was found to be inversely proportional to the toxicity of the solutions.

In the seventeenth *Annual Report* of the Wisconsin Agricultural Experiment Station, Professor Goff has a paper of interest on the development of flower buds on a number of fruit plants, in connection with the temperature curve for March and April, in which their development was found to lie.

Students of leaf-form and position will be interested in a paper by Raciborski in the *Annales du Jardin Botanique de Buitenzorg*, Vol. II, Part I.

"Open Spaces for the People" is the title of an article by Philip MacMahon, curator of the Brisbane Botanic Gardens, in the *Queensland Agricultural Journal* for December, in which a general plan is given of that garden and of promenades that it is suggested may be connected with it.

Some profit and a little amusement may be obtained from an examination of a recent *Consular Report* on "school gardens in Europe," among which Consul-General Lincoln of Antwerp includes the Kindergartens of that city.

A compendious volume of statistics concerning the use of wood pulp in foreign countries is published as Vol. XIX of the *Special Consular Reports* of our Government.

The "Diamond Jubilee Number" of the *Gardeners' Chronicle* for January 5 contains portraits of Lindley, Paxton, Berkeley, and

Darwin, all of whom contributed matter of botanical or horticultural interest to the earlier volumes of the journal, which, though agricultural in name, has always been of interest and value to the botanist.

The double number of the *Botanische Zeitung* (Abtheilung I) for December 1 is devoted to Brunfels, a botanist of four hundred years ago.

The Fern Bulletin for January opens with a portrait of Professor Underwood.

PALEONTOLOGY.

Dean's "Palæontological Notes."[1] — This elaborate memoir of upwards of forty pages, six plates, and eighteen text-figures, is one of the most important contributions to the literature of Devonian Arthrodires that has yet appeared in this country. It has for its twofold object a minute description of the skeletal structures in Mylostoma, Stenosteus, and Selenosteus (the last two being here made known for the first time), and a discussion of the characters and relationships of the whole group of Arthrodires, with the improvision of a new system for their arrangement.

Four of the quarto plates are admirably lithographed by the author from original specimens; the other two are from photographs. Not the least valuable and suggestive feature is the interspersion throughout the text of numerous diagrams showing the arrangement of plates in the cranial, dorsal, and ventral armor of different genera of Arthrodires. Restorations of this nature are not only useful for the graphic information they convey, but they afford an extremely convenient means of comparison. The interesting modifications displayed by Mylostoma and Dean's two new genera, especially as regards their dentition, constitute a welcome addition to our knowledge of this group. Owing to their poor preservation, the difficulty of deciphering the details which the author has painstakingly worked out and skillfully reconstructed must have been very great, and obviously none but an expert could have succeeded.

[1] Dean, Bashford. Palæontological Notes. I, On Two New Arthrodires from the Cleveland Shale of Ohio; II, On the Characters of Mylostoma, Newberry; III, Further Notes on the Relationships of the Arthrognathi. *Mem. N. Y. Acad. Sci.*, vol. ii (1901), pt. iii.

Of more general interest, however, are the author's views as to the relationships of the so-called "Arthrognathi" (= Arthrodira + Anarthrodira, the latter comprising only the genera Macropetalichthys and Holopetalichthys). Excluding them from both Pisces and Ostracoderms, Dean assigns them the rank of an independent class, which he conjectures may have been descended from primitive forms like Lanarkia in the Silurian. The prime reason for removing Arthrodires from Pisces rests upon the interpretation of their jaw-elements, which Dean regards as merely dermal ossifications, showing "not the slightest evidence of their relation to endoskeletal or gill-arch jaws." There is, however, strong presumptive evidence that a cartilaginous mandibular arch was present, the distal portion of which ensheathed the lower dental plate ("gnathal," Dean), and the proximal portion, or suspensorium, was attached to the head-shield. How, for instance, is one able to conceive of the attenuated mandibles of Titanichthys, except as imbedded in tissues corresponding to the Meckelian cartilage?

The author advances some ingenious theories to explain the evolution of the articular joint between cranial and dorsal shields characteristic of Arthrodires, and, giving free rein to his imagination, speculates on how such a joint might have arisen in the head-shield of Macropetalichthys. A slight impediment exists, however, in the way of accepting his conclusions, for the reason that we cannot admit any of his premises. Dean assumes, and so, too, have Newberry, Cope, and Eastman before him, for that matter, that a valid basis of comparison exists between this enigmatical form and various specified genera, where the facts prove such is not the case; also that the arrangement of cranial plates and sensory canals in the genus under consideration is homologous with that pervading Arthrodires generally, which is an egregious error.

The fact of the matter is that all writers on Macropetalichthys have been misled by deceptive appearances, perhaps to some extent also by preconceived ideas, and its osteology has not yet been correctly interpreted. Eastman's and Dean's suggestion that there is a superficial system of investing plates arranged independently to a distinct substratum of bony elements is unsubstantiated, if not disproved; and still more improbable is the notion that the "head-shield" is made up of combined cranial and dorsal shields. The transverse septum peculiar to this genus is an internal structure situated a long distance in advance of the posterior cranial border, and recalling in a measure the inwardly directed processes on the

inferior aspect of the postorbital in Dinichthys. There are in Macropetalichthys no movable ginglymoid joints, neither dorsal nor ventral armor so far as known, and apparently no ossified lower jaw. In short, this genus and the accompanying Asterosteus are as far removed from Arthrodires as are the Ostracoderms, and should perhaps be included in the same subclass with the latter. Their canal systems and cranial plates can be no more homologized with those of Arthrodires than with Stegocephalians, and the most we can affirm is that their arrangement is bilaterally symmetrical, and in a few respects similar or paralleled. Dean's text-figures 12 and 13 are objectionable, therefore, in so far as they depict merely fanciful conditions; and in Figs. 15 and 16 the overlap of the clavicular is shown, but the plate itself is omitted.

Apart from this parenthetical discussion, as it were, of extraneous genera, the author's generalizations respecting Arthrodires, his subdivision of them into several new families, and summary of their characters, reflect the advanced ideas of an investigator who has greatly enlightened us as to their structure and interrelationships.

C. R. E.

Jurassic Fossils from Alaska.[1] — In this paper Dr. Pompeckj has given a revision of all the known Jurassic fossils of Alaska and has described a number of new forms. According to Dr. Pompeckj the Lias is represented at Kialagvik, or Wrangell Bay, on the Peninsula of Alaska, as shown by the presence of *Amaltheus whitearesi* White, *Lillia howelli* White, *L. kialagvikensis* White. This fauna was described by Dr. C. A. White as of Upper Jurassic or Lower Cretaceous age.

The Kelloway stage of the Middle Jurassic is represented at Katmaiskoj on the southeastern side of the Alaskan Peninsula, and on the northwestern side of the Kadiak Island. The former locality furnished the following fossils:

Cadoceras wosnessenski Grewingk, *C. grewingki* Pompeckj, *C. catostoma* Pompeckj, *Belemnitella*, *sp.* indet., *Aucella*, *sp.* indet., *Inoceramus*, *sp.* indet. The locality on Kadiak Island yielded the following fossils: *Phylloceras subobtusiforme* Pompeckj, *Cadoceras* conf. *wosnessenski* Grewingk, *C. grewingki* Pompeckj, *C. Schmidti* Pompeckj, *C. petelini* Pompeckj, C., *sp.* indet., *C. stenoloboide* Pompeckj. These fossils show a wide distribution of the sea during the Kelloway stage

[1] Pompeckj, J. F. Jura-Fossilien aus Alaska, *Verhandl. Kais. Russ. Mineralog. Gesell. St. Petersbourg*, Ser. 2, Bd. xxxviii (1900), Nr. 1.

of the Middle Jura, but the occurrence of Lias in the same region shows that Neumayr's hypothesis of a great transgression of the sea in Middle Jurassic time in the arctic region will not hold good. Marine deposits existed there even before Jurassic time, as shown by the occurrence of Upper Triassic deposits in Alaska.

J. P. S.

The Permian of Armenia.[1] — The strata of Djulfa in Armenia are classic in geological literature, having long ago been assigned to the Subcarboniferous on account of the supposed occurrence of *Goniatites striatus*. But a revision of the fauna, based on a new collection made by Prof. F. Frech, shows that these beds belong to the Permian, for there is a mixture of Paleozoic and Mezozoic types. Their Paleozoic age is shown by the occurrence of typical Permian brachiopods, such as are known in Russia and India, and of the goniatite genus Gastrioceras, which has never been found above the Permian. On the other hand, the genera Hungarites and Otoceras are known there, which elsewhere are not found below the Trias. The evolution of Hungarites from the simple forms of Armenia into the complex development as known in the Trias of Siberia and India is worked out by Dr. von Arthaber in a most convincing manner, and is a good argument against useless multiplication of generic names in a phylogenic series.

J. P. S.

Notes. — Dr. Diener (*Beitr. Palaeontol. Oesterreich-Ungarns*, Bd. XIII, 1900) has continued his detailed studies of the Triassic faunas in this contribution, treating of the Muschelkalk zone of *Ceratites trinodosus*. He describes a new genus, Arthaberites, of the family Pinacoceratidæ, resembling Pseudosagoceras Diener of the Lower Trias of Siberia, and possibly descended from it. The fauna described shows a strong resemblance to that of the Bosnian Muschelkalk long since made known by the works of F. von Haner. It consists of numerous species of Ceratites, Anolcites, Celtites, Proarcestes, Joannites, Procladiscites, Megaphyllites, Sageceras, Arthaberites, Pinacoceras, Norites, Monophyllites, Sturia, Gymnites, Ptychites, Nautilus, Orthoceras, Atractites. Many of these species had not before been found in the Alps, and their discovery is of material aid in correlating the Alpine strata with those of the other Triassic provinces.

[1] Arthaber, G. von. Das jüngere Palaeozoicum aus der Araxes-Enge bei Djulfa, *Beiträge zur Palaeontologie Oesterreich-Ungarns und des Orients*, Bd. xii (1900), Nr. 4.

Dr. Whiteaves (*Geol. Survey of Canada*, Vol. I, Part IV) revises his published papers on the paleontology and stratigraphy of the Queen Charlotte Islands, many old species being renamed, as further studies have shown their designations to be untenable. Several new species of brachiopods and Mollusca have been obtained by later collectors and are added in this paper. Among the ammonites may be noted the predominance of Desmoceras and Olcostephanus, also the absence of Baculites and Pachydiseus, which are characteristic of the Cretaceous of Vancouver Island. The faunas here described seem to include both Knoxville and Horsetown beds of the Californian section, as shown by such characteristic species as *Phylloceras knoxvillense* Stanton, *Lytoceras batesi* Trask, *L. sacya* Forbes, *Desmoceras breweri* Gabb, *D. haydeni*, and *Aucella crassicollis* Keyserling.

The revision of the nomenclature will be exceedingly acceptable and useful to students of West-Coast stratigraphy.

Dr. Sokolow (*Mem. Comité Geol. St. Petersburg*, Vol. IX, No. 5, 1899) has made an interesting study of the brackish-water basin fauna that lies immediately between the Mediterranean stage of the lower Miocene and the Sarmatic stage of the middle Miocene Tertiary of Russia. The Mediterranean stage represents the deposits of the disappearing ancient Mediterranean Sea, and the Sarmatic beds are the deposits of the ancient Black Sea. In this paper we have a study of the fauna transitional between the two epochs and the two basins. In consequence of this the fauna is a mixed one, showing both marine and brackish-water types, due to the rapidly changing physical geography and the development of the extensive brackish-water seas that covered southern Russia in later Miocene time.

Most students of the Triassic paleontology of the Alps occupy themselves with the cephalopods, while the other groups are neglected. But Dr. Kittl (*Ann. k. k. Naturhist. Hof-Museum. Wien*, Bd. XIV, Nr. 1, 2) has given an elaborate revision of the gastropods of the classic St. Cassian beds of the southern Alps, describing many new species and making known a rich fauna. The detailed stratigraphy and correlation of these beds are taken up, and much new light is thrown on the relations of the various fossiliferous horizons of the southern Alps.

In the *Bulletin* of the Harvard Museum of Comparative Zoölogy Mr. C. R. Eastman gives descriptions and figures of two species of extinct gar pikes, *Lepidosteus atrox* Leidy and *L. simplex* Leidy, from

the Eocene Green River shales of Wyoming. Most of the fossil gar pikes of America have been hitherto known from bare fragments scantily described. Mr. Eastman's specimen of *L. atrox* is especially complete, as large as an alligator gar, and very much like it in appearance. In fact it "lacks any positively archaic features," and Mr. Eastman regards it as "obviously the direct progenitor of the alligator gar, *L. Tristachus*." Mr. Eastman finds no trace of the earlier ancestry of Lepidosteus. The gar pikes "blossom forth suddenly and fully differentiated at the dawn of the Tertiary without the least clue to their ancestry, unheralded and unaccompanied by any intermediate forms, and they have remained essentially unchanged ever since."

In the *Bulletin* of the Kansas University, Vol. I, No. 2, Prof. S. W. Williston describes and figures many teeth of sharks found in the Cretaceous rocks of Kansas, his paper being a very useful contribution to this difficult branch of paleontology. In the matter of nomenclature, apparently, Agassiz's name, Oxyrhina, should not be used instead of the earlier Isurus of Rafinesque, and Scylliorhinus of Blainville has unfortunately clear priority over Scyllium Cuvier.

PETROGRAPHY.

Geology of the Black Hills. — Irving's contribution to the geology of the Northern Black Hills adds a great deal to our knowledge of this interesting region, especially from the point of view of petrography. The author agrees with Crosby, rather than with Russell, in regarding the larger intrusives of the district as laccolites and not as plugs. He finds also an abundance of sills and dikes. The dikes characterize the Algonkian slates, the sheets and laccolites the Cambrian shales. The Carboniferous limestone is almost devoid of intrusions of any kind. The principal types of rocks recognized are a quartz-agirite-porphyry, tinguaite, phonolite, trachytoid-phonolite, quartz-porphyry, mica-diorite-porphyry, dacite, tonalite, and augite-vogesite. The phonolites and quartz-porphyries are the most abundant types, with the quartz-agirite-porphyries and the diorite-porphyries fairly abundant. There is such an intimate gradation between the different types that they appear to be related genetically. In the pre-Cambrian rocks, dikes and possibly plutonic

intrusions of basic igneous magmas took place before the metamorphism of the Algonkian sediments.

The author does not agree with Van Hise in ascribing the crystalline character of the schists near Deadwood to the agency of intrusives. He regards the metamorphism as "dynamic" rather than "contact."[1]

Isle Royale and Keweenaw Point Volcanics. — In Vol. VI of the Michigan Survey, Lane[2] and Hubbard[3] give a great many interesting details concerning the petrography of the Keweenawan eruptives.

One of the most interesting features of Lane's paper is his discussion of the cause of the variation in coarseness of grain in rocks, and the application of his conclusions to the problem of the nature of the Isle Royale and other rock-sheets. From the fact that the Isle Royale sheets are characterized by an increase in the size of grain to their centers, he concludes that they are surface flows or lavas. On the other hand, he concludes that Lawson's view as to the intrusive character of the diabase sheets in the Huronian beds of the north shore of Lake Superior is confirmed by the fact that they are characterized by a rapid variation in size of grain for the first few feet from their contacts with the surrounding rocks, and then by a central coarser belt of tolerably uniform grain.

Another interesting chapter in the report is that on the differences in structure between small intrusive basic masses and their corresponding effusive forms. To the already recognized distinctions between these two forms of igneous rocks, Lane adds that the miarolitic cavities in intrusive masses naturally become filled with other minerals than the zeolitic and chloritic ones characterizing the corresponding pores in effusive rocks. Among the most important of these minerals is quartz, which often appears in diabase dikes as micropegmatitic intergrowths in the central portions of their masses. The microscopic and chemical features of the Isle Royale lavas are described in some detail.

The report by Hubbard deals mainly with the structural problems presented by the interbedded lavas and sandstones in Keweenaw Point. It contains a few notes in the petrography of the various lava beds.

[1] *Ann. New York Acad. Sci.*, vol. xii, p. 187.

[2] Lane, A. C. Geological Report on *Isle Royale, Michigan. Geol. Survey of Michigan*, vol. vi, pt. i.

[3] Hubbard, L. L. Keweenaw Point, with Particular Reference to the Felsites and their Associated Rocks, *ibid.*, vol. vi, pt. ii.

Occurrences of Differentiated Magmas. — As the result of a rapid survey of the Magnet Cove, Arkansas, igneous area, Washington[1] concludes that the complex described by Williams represents an excellent though peculiar example of a highly differentiated magma, probably in the form of a laccolite, and not a series of independent intrusions. The rock types present in the area form a regularly graded series, ranging from foyaite, through leucite-porphyry, shonkinite-porphyry, ijolite, and biotite-ijolite to jacupirangite. The distribution of the rocks is, however, abnormal, since the basic varieties are near the center of the supposed laccolite, and the acidic varieties in its periphery. The author explains this abnormality by supposing the magma to be a solution in which the solvent was in great excess. This solidified first on the outside, leaving a more concentrated, and consequently a more basic solution within. The solvent continued to separate by crystallization as a more and more basic rock, as the cooling continued inward, until, finally, at the center the most concentrated and most basic material solidified as **jacupirangite.**

Spurr[2] has compared the order of succession of the intrusions in the Great Basin and has found it to be in general the same throughout the district, although at any given place certain members of the series may be lacking. This succession as worked out is as follows: acid rocks (rhyolites), siliceous intermediate types (andesites), acid rocks, associated with basalts, basic intermediate types (more basic andesites and aleutites), basic rocks (basalts), with associated rhyolites. The Great Basin appears to have been underlaid by a single body of molten magma which supplied at different times lavas of similar composition to all the different parts of the overlying surface. Since this succession is different from any described from other regions, the author suggests that the first rhyolite is the end member of a series of differentiates, and that the andesites are the beginnings of two distinct cycles of differentiation. He further suggests that during the first completely recorded cycle beginning with the earlier andesite the siliceous differentiates of this magma were erupted in preference to the basic differentiates, while in the second cycle the basic members were the predominant extravasations. It must be borne in mind that the processes of differentiation are independent of the causes that produce expulsion of lavas, and hence the records of the differentiation, as observed on the

[1] *Bull. Geol. Soc. Amer.*, vol. xi, p. 389.
[2] *Journ. of Geol.*, vol. viii, p. 621.

surface, must necessarily be incomplete. For this reason the succession of lavas in any district should be studied with reference to its general features rather than to its details, and care must be taken to exclude from the discussion the intermediate rocks formed by mixing of the different types.

The great batholite forming the height of land between the highland mountains south of Helena and Butte, Montana, is composed of rocks presenting a wide variation in composition.[1] The main rock is a hornblende-granite (I) resembling closely a quartz-monzanite. At Butte the rock is a little more basic (II). Great masses of aplite (III), possessing often a lenticular shape, are associated with the granites, perhaps as a differential product of the hornblende-granite, the Butte granite being the more basic differentiate. At the periphery of the batholite basic dikes penetrate the surrounding sedimentaries.

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	H_2O	Various	Tot.
I.	67.12	.48	15.00	1.62	2.23	3.43	1.74	4.52	2.76	.67	.31	= 99.88
II.	64.03		15.58	1.96	2.83	4.20	2.15	4.11	2.76			
III.	77.05	.12	12.84	.56	.14	.57	tr.	5.52	2.81	.70		= 100.31

As the result of his studies on the igneous rocks of the Bohemian Mittelgebirge, Hibsch[2] concludes that the succession is as follows: (1) flows of basalt, preceded by phonolite in a laccolite mass, (2) flows of tephrites, stock intrusions of essexite, dikes of camptonite, monchiquite, bostonite, gauteite, and sodalite-porphyry, (3) basalts, trachytes, phonolites, and dikes of tinguaite and eleolite-porphyry.

Hackman[3] has reëxamined the ijolite in the Parish of Kunsamo, Finland. He finds the main portion of the several massifs to consist of the normal rock (I), but in addition to this he recognizes also the following as differentiation products — a nepheline-rich ijolite (II), a soda sussexite (III), a magnesian essexite (IV), and a pyroxene-syenite which may, however, be a rock formed by the solution of the granite surrounding the igneous rock in the magma of the latter.

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	Na_2O	K_2O	P_2O_5	Total
I.	42.89	1.05	19.45	3.34	3.09	.39	10.99	3.74	10.03	2.17	1.54	= 98.68
II.	43.02	.63	24.63	3.59	2.17		5.47	1.96	14.81	2.99	.70	= 99.97
III.	47.43	.10	23.60	4.59	1.20		4.42	.67	15.08	2.00		= 99.09
IV.	45.66	2.75	11.64	3.57	10.61		9.11	11.08	2.60	.44	.26	= 99.92

[1] Weed, W. H. *Journ. of Geol.*, vol. vii, p. 737.
[2] *Min. u. Petrog. Mitth.*, Bd. xix, p. 488.
[3] *Bull. Com. Geol. d. Finlande* (1900), No. 11.

Graphic Representation of Rock-Analyses. — Müggs[1] proposes a scheme for the graphic representation of the chemical composition of rocks based on Brögger's and Michel-Lévy's scheme. The relative percentages of the various metallic constituents are indicated by means of polygons drawn through points plotted on eight radii. Within this is a second polygon which represents the silica content. The size of the latter is determined by the percentage of this constituent present, and the relative sizes of this polygon and the outer one are an indication of the rock's acidity. In constructing the inner polygon the percentage of silica present is divided into eight equal parts, and each is plotted in one of each of the radii. In plotting for the outer polygon the Al_2O_3 is divided into three parts determined by the proportion borne by K_2O and Na_2O to one another and the other bases.

The Origin of the Glaucophane-Schists. — Rosenbusch, as is well known, has hitherto suspected that true glaucophane-schists are genetically associated with sedimentary rather than with igneous rocks, but so few analyses of these schists have been made that the supposition has not been capable of chemical investigation. In a recent[2] article, however, he shows that some of the schists have the composition of a normal gabbro magma. In these epidote, zoisite, lawsonite, prehnite, margasite, and garnet are usually if not always present. Rocks of this kind are closely related to amphibolites. Other glaucophane-schists he still believes to be metamorphosed sediments, but analyses of these are lacking.

Washington[3] supplements Rosenbusch's investigations in an article in which he records and compares fifteen analyses of these schists. Upon comparing their analyses he discovers that the rocks fall into two main groups, a very basic group with a content of SiO_2 varying between 46% and 49.7% and a very acid group with SiO_2 between 74.5% and 82.5%. The former he believes, with Rosenbusch, to be derived from gabbros, diabases, or their tuffs. The acid glaucophane-schists he thinks are derived from cherts, quartzose shales, or quartzites. The basic forms scarcely differ from the amphibolites in chemical composition, the formation of the one or the other kind of schists depending probably upon conditions of metamorphism.

[1] *Neues Jahrb. f. Min.* etc., Bd. i (1900), p. 100.
[2] *Sitzb. kön. preuss. Ak. Wiss. Berlin*, Bd. xlv (1898), p. 716.
[3] *Amer. Journ. Sci.*, vol. xi (1901), p. 35.

CORRESPONDENCE.

Editor of the American Naturalist:

SIR, — In his valuable paper on "the Snakes of New York State," in the February number of the *Naturalist*, Dr. Eckel enumerates two forms as doubtfully occurring in the state upon the authority of Cope who, in his *Crocodilians, Lizards, and Snakes of North America*, records specimens as being in the collection of the National Museum. Dr. Eckel properly doubts the correctness of the statements, and I am in a position to corroborate him.

The first is a specimen of *Osceola doliata clerica*, United States National Museum, No. 1407. The value of the locality "New York" may be inferred from the fact that the specimen was received in 1858 from the Museum d'Histoire Naturelle in Paris, together with No. 1405, *Elaps lemniscatus*, and No. 1406, *Dromicus cursor*, — all three said to have come from New York. It is simply a case of French geography.

The other case is that of a *Natrix fasciata erythrogaster*, United States National Museum, No. 9984, said to have come from Westfield Falls, Conn. In this case the geography is correct enough, but the identification is wrong. I have just examined the specimen; it is a *Natrix sipedon* pure and simple!

Thus Dr. Eckel may safely eliminate Nos. 10 and 13 from his "check list."

LEONHARD STEJNEGER.

U. S. NATIONAL MUSEUM,
February 15, 1901.

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AMERICAN NATURALIST

VOL. XXXV. *June, 1901.* NO. 414.

THE COMPOUND AND MIXED NESTS OF AMERICAN ANTS.[1]

WILLIAM MORTON WHEELER.

PART I. OBSERVATIONS ON A NEW GUEST ANT.

OF the many symbiotic relations known to exist between ants and other living organisms, whether animals or plants, few are more interesting than the relations between ants of different species or even genera that live together in the same nests on terms of mutual toleration or intimacy. In this country, nevertheless, studies like those of Forel ('74), Adlerz ('84, '86, '96), and Wasmann ('91) on the compound and mixed nests of European ants have scarcely been undertaken, notwithstanding the fact that our own ant fauna is known to present numerous cases no less remarkable than those which have been so carefully studied abroad. Sufficient evidence of the truth of this remark will be found in the description of a hitherto unknown form of compound nest which is made the basis of the present paper. This is in many respects so unlike any of the recorded compound nests that it seems worth while, if only

[1] *Contributions from the Zoological Laboratory of the University of Texas*, No. 14.

for the sake of comparison, to follow it with a consideration of the other forms of mixed and compound nests that are known to occur on our continent. While it thus becomes necessary to review much that is well known to the myrmecologist, I hope at the same time to call the attention of entomologists, who may have wearied of collecting and mounting our comparatively well-known beetles and butterflies, to an extensive subject, which is as interesting to the collector as it is fascinating to the philosophical observer. Ants' nests of the mixed and compound varieties are of sporadic and often very rare occurrence, so that there is great need of many more observations extending over large portions of our country. While reviewing the various forms of nests in the second part of my paper, I shall include a brief consideration of some interesting compound nests that have recently come under my observation in Texas and Mexico.

During the late afternoon of August 1, 1900, while walking over one of the Litchfield Hills near Colebrook, Connecticut, I found a number of nests of the common red-brown Myrmica (*M. brevinodis* Emery) under some small stones that were rather deeply imbedded in the moss bordering the exposed glaciated rock of the hilltop. In four of these nests which were rather close together and not very populous I detected among the Myrmica workers a few decidedly smaller and more yellowish ants of a different species running about on the up-turned lower surface of the stones. As my stay in Colebrook was at that time limited to a few days, I carefully replaced the stones in the moss after preserving a few of each of the two species. The smaller ants were sent to Professor Emery of Bologna, who pronounced them to be a new species of Leptothorax allied to *L. canadensis* Provencher.

Later in the month of August I returned to Colebrook and at once revisited the Myrmica-Leptothorax nests. Two of them had disappeared, as if in resentment of my former intrusion into their peaceful life on the hilltop. The third nest contained only a few Leptothorax workers. The fourth nest was in good condition and was dug up *in toto* and carried home in a canvas bag. For several days I searched diligently, but in vain, on all the hills about Colebrook for more of these double nests,

though single nests of the Myrmica were frequently found. My observations were therefore to be confined to only one nest.

The worker of *Myrmica brevinodis*, which I shall not pause to describe, is represented in Fig. 1. The Leptothorax, however,

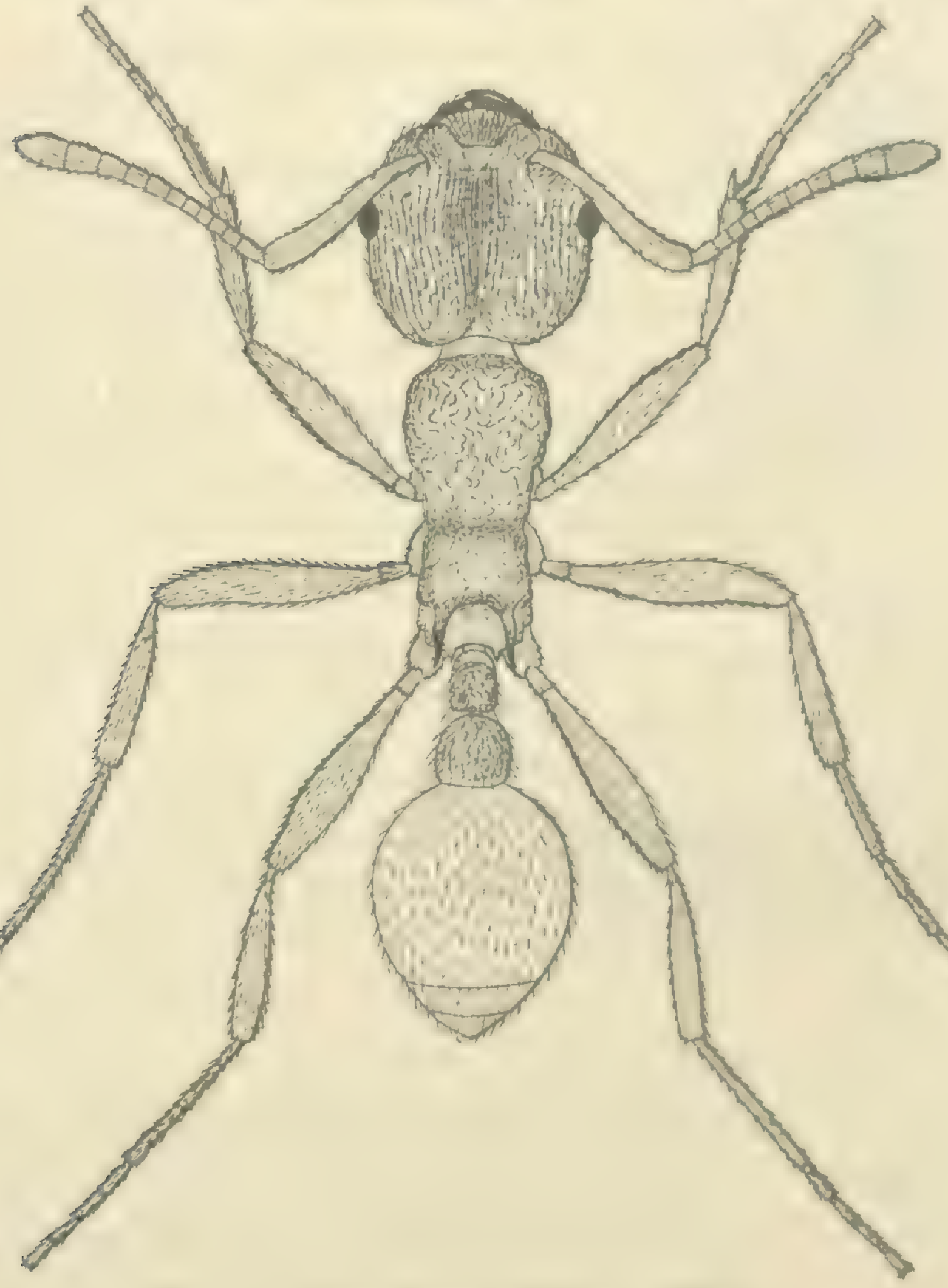

FIG. 1. — *Myrmica brevinodis* Emery. Worker.

is of greater interest in this connection and certainly merits a description before we proceed with any observations on its behavior.

Leptothorax emersoni n. sp.[1]

Worker (Fig. 2). Length 2.5–3.5 mm.

Brownish yellow; upper surface of the head except the mandibles, clypeus, and a narrow postclypeal and occipital

[1] I take pleasure in dedicating this species to Mr. Ralph Emerson in memory of the many happy hours which we spent together at Rockwell Hall in Colebrook.

strip, dark brown, as is also a very broad band across the middle of the first abdominal segment and the basal half of each of the succeeding segments. Hairs covering the mandibles, antennæ, legs and body, whitish ; those on the body rather long, coarse and truncated, but scarcely clavate at their tips; those on the limbs tapering and less conspicuous.

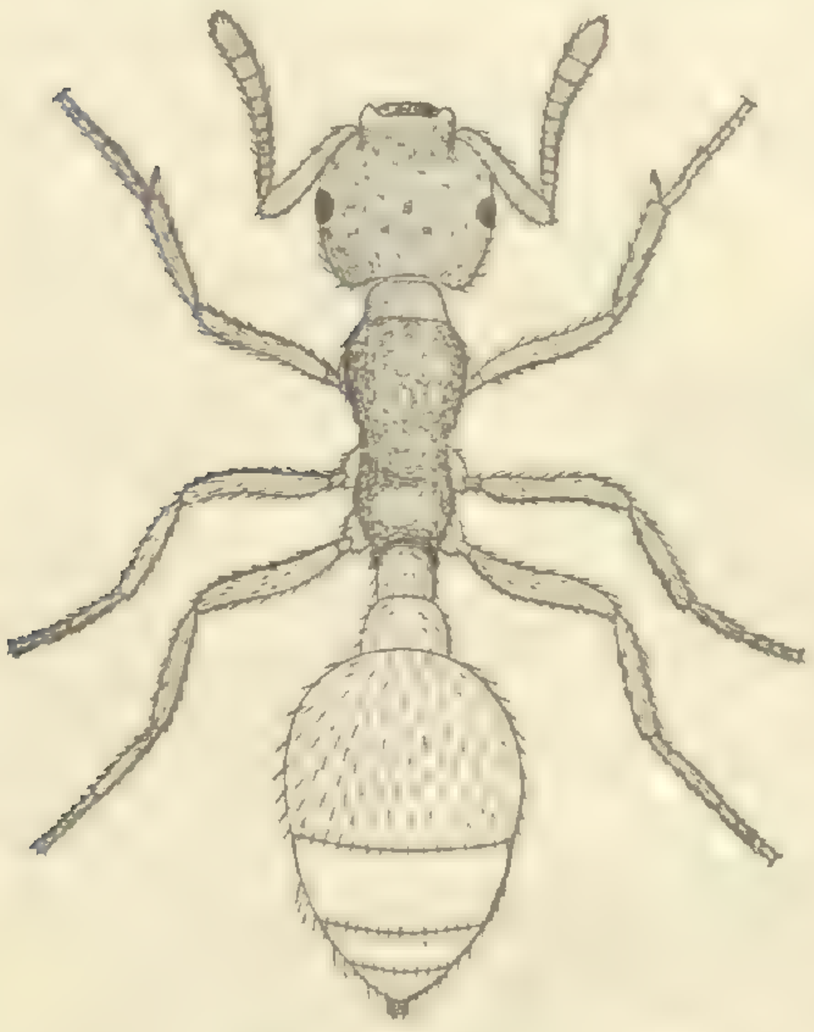

FIG. 2. — *Leptothorax emersoni* n. sp. Worker with ocelli.

Mandibles rather coarsely striated longitudinally and provided with a few setigerous punctures; cutting edges black. Clypeus moderately convex, smooth in the middle but with a few delicate longitudinal rugæ on either side. Antennæ 11-jointed. Head opaque, above and on the sides coarsely and longitudinally reticulate-rugose, the areolæ enclosed by the rugæ being indistinctly and finely punctate. In the mid-dorsal region of the head the rugæ are close together and their longitudinal course is very distinct, but in the antennal foveæ and on the cheeks and the sides of the head they are farther apart and more reticulate. Some of the workers have two or three minute ocelli which are most easily seen in alcoholic specimens. Thorax faintly but distinctly constricted at the meso-metanotal suture; opaque, above and on the sides less distinctly reticulate-rugose than the head. Anterior portion of the pronotum, metanotum, and lower pleuræ punctate; metanotal spines slightly longer than broad at their bases, nearly parallel, terminating in broad, flattened, blunt points. Petiole about twice as long as broad, subopaque, finely punctate, with a pointed dorsal cone, the anterior and posterior surfaces of which are of nearly equal length and inclination, the former being very slightly concave, the latter flat when seen in profile. Postpetiole smooth, subglabrous, hemispherical. Abdomen rather broad, distinctly flattened dorso-ventrally, and very glabrous.

Female. Length nearly 4 mm.

Thorax more opaque, more distinctly rugose, and of a darker brown color than in the worker.

Male (Fig. 3). Length 2.75–3 mm.

Coloration brownish yellow like that of the worker; head, thoracic dorsum, abdomen, and the middle portions of the femora and tibiæ somewhat darker. Wings colorless, with very pale veins and stigmata. Hairs almost completely absent on the head and thorax, short and inconspicuous on the legs, long on the abdomen, but nowhere truncated at their tips.

Mandibles striated, hairy, very small, not distinctly dentate, and far from meeting each other with their blades. Clypeus even in the middle with a few delicate longitudinal rugæ. Head above longitudinally reticulate-rugose; rugæ radiating backwards and laterally from the posterior ocelli as centers. Antennæ 12-jointed; scape scarcely as long as the three first joints of the flagellum taken together; first joint of flagellum very short, the others of uniform thickness but increasing gradually in length towards the tip. Thorax rather smooth, indistinctly punctate; parapsidal and other sutures very distinct; metanotum with two very short rugose projections in the place of the spines. Dorsal projection of the petiole rounded, its posterior slope slightly concave, the anterior convex. Postpetiole hemispherical; abdomen very glabrous, somewhat less flattened than that of the worker.

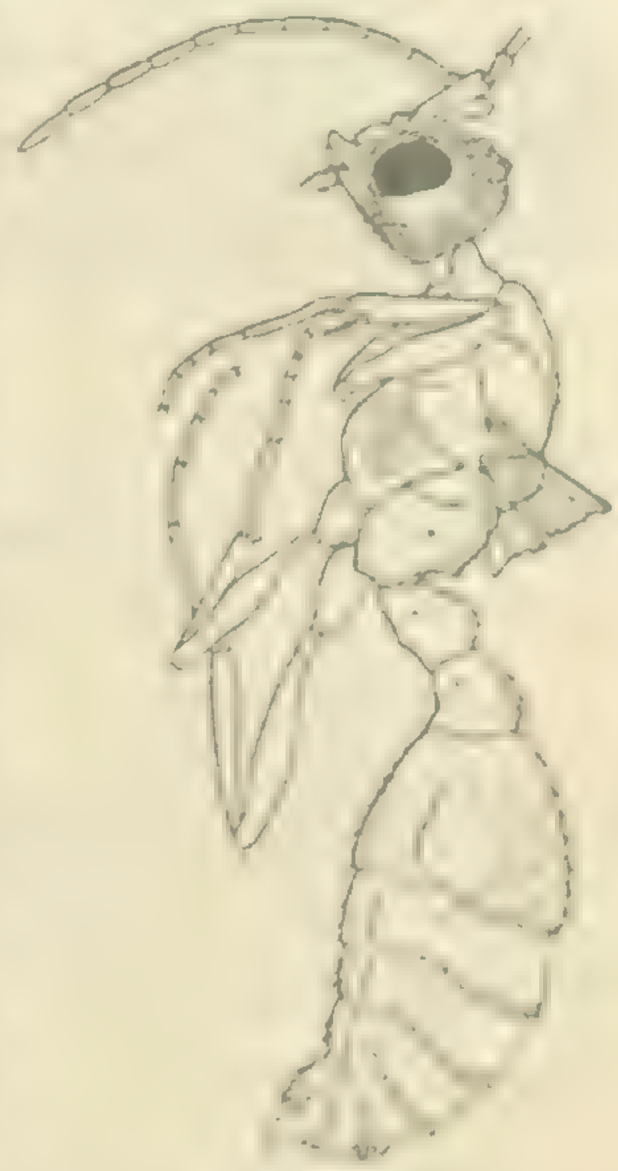

FIG. 3.—*Leptothorax emersoni* n. sp. Male.

Leptothorax emersoni is to be assigned to the small group of North-American species comprising *L. muscorum* Nyl. (also recorded from Europe), *L. canadensis* Provencher, with its variety *yankee* Emery, *L. hirticornis* Emery, and *L. provancheri* Emery. The workers of all these forms have 11-jointed antennæ and a distinct meso-metanotal constriction. That the new species is perfectly distinct from all of these is

quite evident from consulting Emery's table of the North-American species of the genus ('95, pp. 317,318).

The above very incomplete account of the female is drawn from memory, as the single specimen escaped from the nest before it could be described.

Some of the workers, especially those which approached the queen in size, possessed minute ocelli. This is shown by the following measurements of the four workers still in my collection :

No. 1. Length 2.5 mm. No ocelli.
No. 2. Length 2.75 mm. No ocelli.
No. 3. Length 3 mm. Two ocelli.
No. 4. Length 3.5 mm. Three ocelli.

This fact is of some interest, as I shall endeavor to show in the sequel.

On the morning of August 25 the ants were transferred to an extemporized Lubbock nest. This consisted of a board surrounded by water, and a little fine, moist earth placed on the board and covered with a pane of glass. A census of the two species of ants gave the following :

Myrmica : 6 deälated[1] queens ; 7 males ; about 200 workers ; a few eggs ; 23 larvæ, both young and old (but apparently no queen larvæ) ; 8 worker and male pupæ. The latter hatched in the course of a few days.

Leptothorax: 1 deälated queen ; 4 recently hatched males ; 14 workers ; 2 adult larvæ, which soon became male pupæ.

The earth with its occupants was dumped from the bag on to the pane of the Lubbock nest, and the ants, after the first flurry of excitement, began to seek refuge under the glass. As usual the larvæ and pupæ were at once conveyed to a place of safety. While this operation was going on, it was noticed that some of the Myrmica workers carried the Leptothorax larvæ, and the Leptothorax workers reciprocated by occasionally

[1] I feel compelled to coin this term for use in the sense of the German "entflügelt." The term *apterous* cannot be used without confusion, since some ants (Eciton, Dorylus, Leptogenys, Tomognathus) have truly apterous queens. whereas the queens of most species of Formicidæ have well-developed wings, up to the time of their removal after the nuptual flight.

carrying some of the Myrmica larvæ. This action on the part of both species was evidently the result of haste and excitement, as I never saw it repeated subsequently except once, when a Leptothorax carried a Myrmica larva a short distance and then dropped it.

As soon as the excitement had subsided the Myrmicas proceeded to dig galleries in the soft earth between the glass pane and the board, and the Leptothorax at once migrated into them. A few hours later the earth that had been dumped on the pane was carefully removed and replaced by a piece of opaque cardboard which was only lifted from the glass when the ants were under observation. A small dish containing a syrup of sugar and water was placed near the nest. This was soon found by two of the Myrmica workers, which at once gorged themselves with the liquid and returned into the nest, where they proceeded to dole out the store of food to their hungry sisters. It was then that I was able to make my first observation on the mutual relations of the two species of ants. A Leptothorax worker was seen to follow up and to climb on to the thorax of one of the food-distributing Myrmicas soon after it had entered the nest. In this position the little ant proceeded to lick the back of the head and clypeus of the Myrmica with signs of agitation as indicated by the hastening of the tremulous beat of its antennæ and the throwing of its abdomen and postpetiole into stridulatory oscillation. The Myrmica paused as if spellbound by this shampooing and occasionally folded its antennæ as if in sensuous enjoyment. The Leptothorax, after licking the Myrmica's pate, moved its head around to the side and began to lick the cheeks, mandibles, and labium of the Myrmica. Such ardent osculation was not bestowed in vain, for a minute drop of liquid — evidently some of the recently imbibed sugar-water — appeared on the Myrmica's lower lip and was promptly lapped up by the Leptothorax. The latter then dismounted, ran to another Myrmica, climbed on to its back and repeated the very same performance. Again it took toll and passed on to still another Myrmica. On looking about in the nest I observed that nearly all the Leptothorax workers were similarly employed. In one

corner of the nest a number of Myrmica workers had formed a circle about a few of their small larvæ which they were cleansing and feeding. A Leptothorax soon found its way to this cluster and stepped from the back of one ant to that of another, lavishing a shampoo on each in turn and apparently filling its crop with the liquid contributions thus solicited.

This and numerous very similar observations, which could be made at any time on removing the cover of the nest, prove conclusively that the Leptothorax workers demand and obtain their food from the Myrmica workers. The method of soliciting food, however, differs from that of any other myrmecoxenous animals known to me. These animals usually request food by tapping the ant with their antennæ (many myrmecophilous beetles), or stroking its face with their fore feet (Atemeles), but none of these guests are so unconventional as to mount the backs and scratch the heads of their hosts for the purpose of inducing the latter to regurgitate. Even the slave-holding Polyergus and the social parasite Anergates demand and receive food after the manner of other ants. The Leptothorax workers are so persistent in their peculiar attentions to the Myrmicas that I have come to doubt whether the little guest ants ever really feed themselves. Once only was a Leptothorax seen to approach the dish of syrup, lap up a very little of it hastily, and then return to the nest. This happened before the ants had definitely settled under the pane of glass. After that only the Myrmica workers visited the manger, and the Leptothorax usually waylaid them as soon as they had entered the nest. During my first visit to the four natural Myrmica-Leptothorax nests I found the latter species loitering in the outer galleries just under the stone. I am convinced that they prefer this situation in order to be on hand the very moment a food-laden Myrmica enters the nest. The Leptothorax workers often walked on the lower surface of the roof-pane, although they had to turn over to mount the passing Myrmicas. They must do this also in the natural nests, for the specimens taken August 1 were, as above stated, crawling on the lower surface of the stones.

Although the feeding of the guest ants commonly proceeds

as above described, I have noticed that the Leptothorax after mounting a Myrmica sometimes turns about and licks the metathorax or even the abdomen of its host, as if, like Myrmecophila (see Wheeler, '00), it found the surface covered with some agreeable secretion. It seems, therefore, not improbable that the Myrmicas may derive some slight benefit from guests which, like many tonsors, combine the occupation of the barber and bather. It is perhaps unnecessary to add that the Myrmica does not always pay for the shampooing it receives. But the Leptothorax is not discouraged; it merely dismounts and runs about in the galleries till it falls in with another Myrmica.

The Leptothorax workers were never seen to approach the male Myrmicas, and only once did I see one shampooing one of the queens. So conspicuous was this neglect of the two fertile sexes of their hosts and their predilection for the workers, that I was convinced that they habitually ignore the queens and males, because these insects, like themselves, depend on the Myrmica workers for their sustenance and are probably on that account not in the habit of regurgitating.

On the evening of the day on which the ants moved into the Lubbock nest and during a portion of the following day, August 26, the queen Leptothorax wandered about outside the nest as if seeking a more favorable retreat. By 4 P.M., however, she had entered the nest and, with eight of her workers gathered about her and her two mature larvæ, was found occupying a small earthen chamber under the very middle of the roof-pane. This chamber, which had evidently been dug by the Leptothorax, was surrounded on all sides by the large galleries of the Myrmicas. Seen from above, the Leptothorax nest had the appearance of Fig. 4 *a*. The queen, workers, and larvæ, nearly filled the small cavity, *a*, which communicated with a wide Myrmica gallery, *c*, by means of a passage, *e*, too small to admit a Myrmica. Through this narrow passage a few Leptothorax workers entered or passed out from time to time, but several always remained in the nest with their queen. Usually from one to six workers were to be seen soliciting food among the Myrmicas.

Three of the six Myrmica queens, together with the Leptothorax males, were preserved in alcohol, as the nest was somewhat over-crowded with the former species and the latter were continually escaping. The three remaining Myrmica queens stationed themselves some distance apart in the galleries, and each was soon surrounded by a coterie of devoted workers. The larvæ and pupæ were being cared for in two or three different portions of the nest.

The Leptothorax in their small central nest passed their time in fondling and feeding one another or in lying motionless as if asleep, covering the two larvæ which had been placed in the bottom of the nest. The queen was assiduously fed by the workers and was never seen to leave the nest after once taking possession of it. On several occasions she was observed to throw one of the workers down on its back and to hug and kiss it in the most animated manner. It was not easy to decide whether this behavior signified maternal affection, the presence of some form of the play instinct, or the more prosaic feeling of hunger. I incline to the last possibility, although the action certainly resembled the affectionate struggles of a cat with her kitten.

During the remainder of this day (August 26) the Leptothorax nest remained in the condition represented in Fig. 4. By 8 o'clock the following morning, however, the bottom of the nest had been dug somewhat deeper, its narrow entrance had been closed up and a new one, equally tenuous, had been opened in a different position (Fig. 5 *r*). The two larvæ had become male pupæ. By noon the queen had laid three elliptical white eggs of rather large size. At 1 P.M. the Myrmica workers discovered the hiding place of their little companions, and two of them in single file shouldered their way through the narrow passage, *r*, enlarging it as they proceeded. As soon as the head of the first Myrmica appeared in the chamber, the Leptothorax, which had been attending to their morning toilet and to that of their larvæ and to the careful arrangement of their eggs, turned to meet the intruders. For an instant I fully expected to see a fierce battle, but I had misjudged the Leptothorax character. To my surprise the Myrmica and

her companion on entering the chamber were received with a profusion of shampooing. The large Myrmicas, though sadly crowding the occupants of the little chamber, let themselves

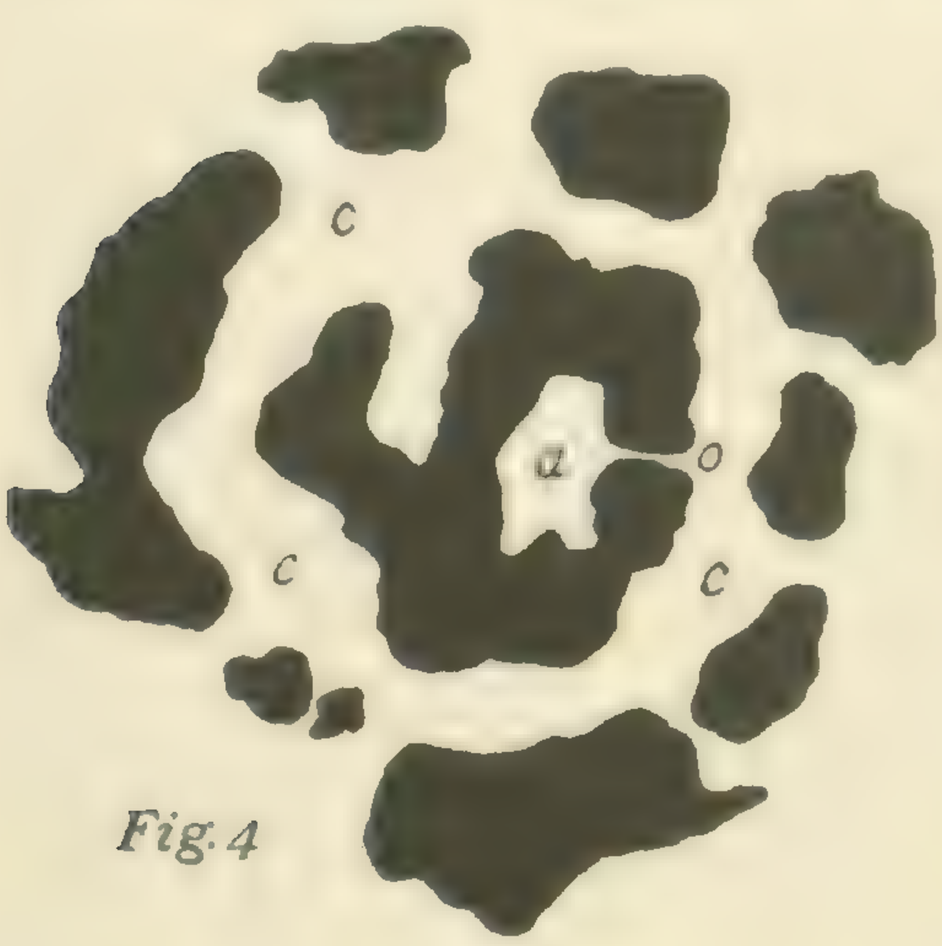

Fig. 4

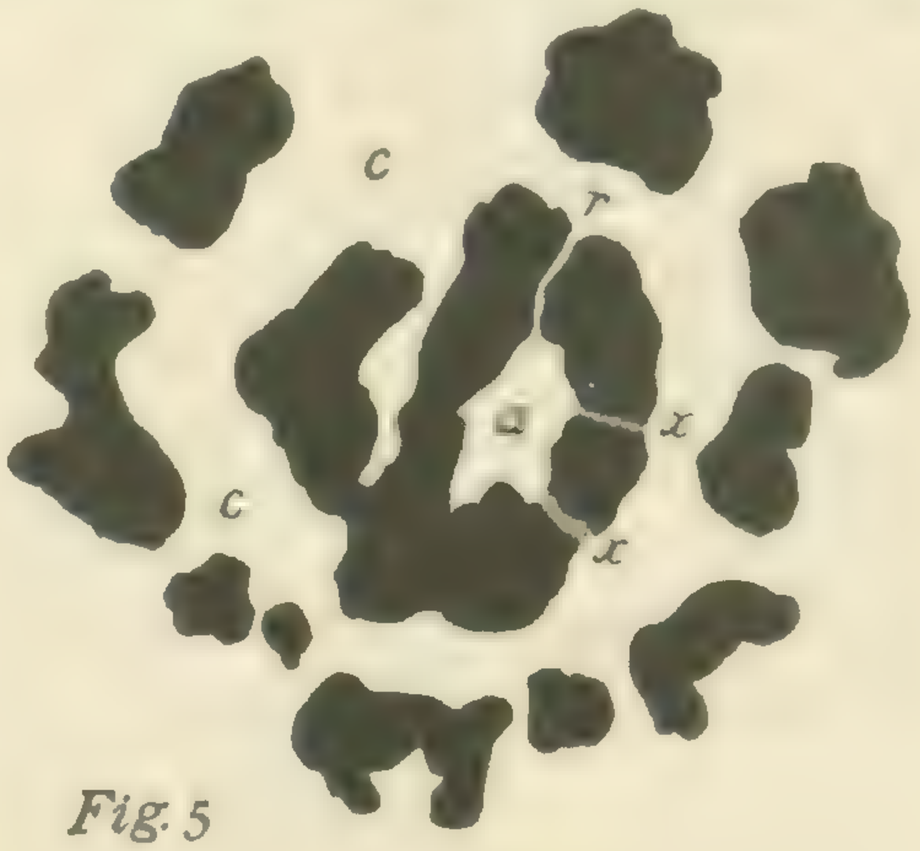

Fig. 5

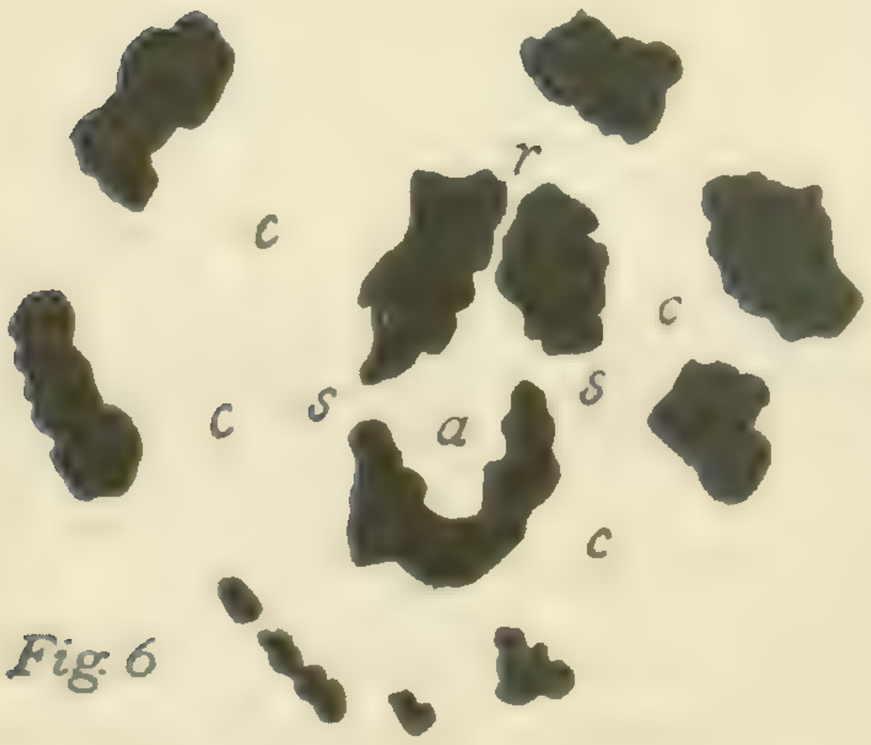

Fig. 6

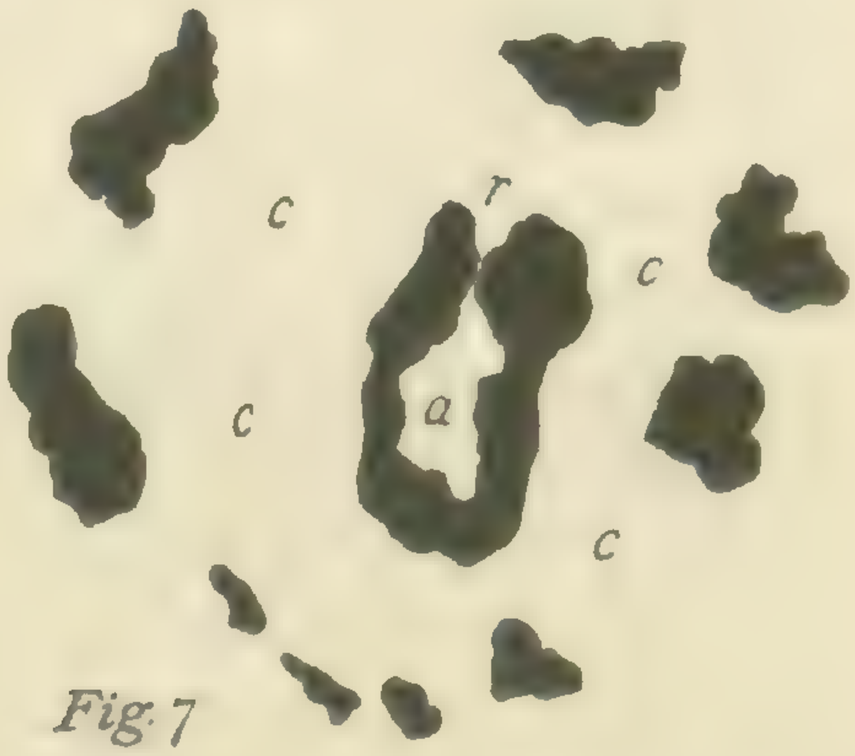

Fig. 7

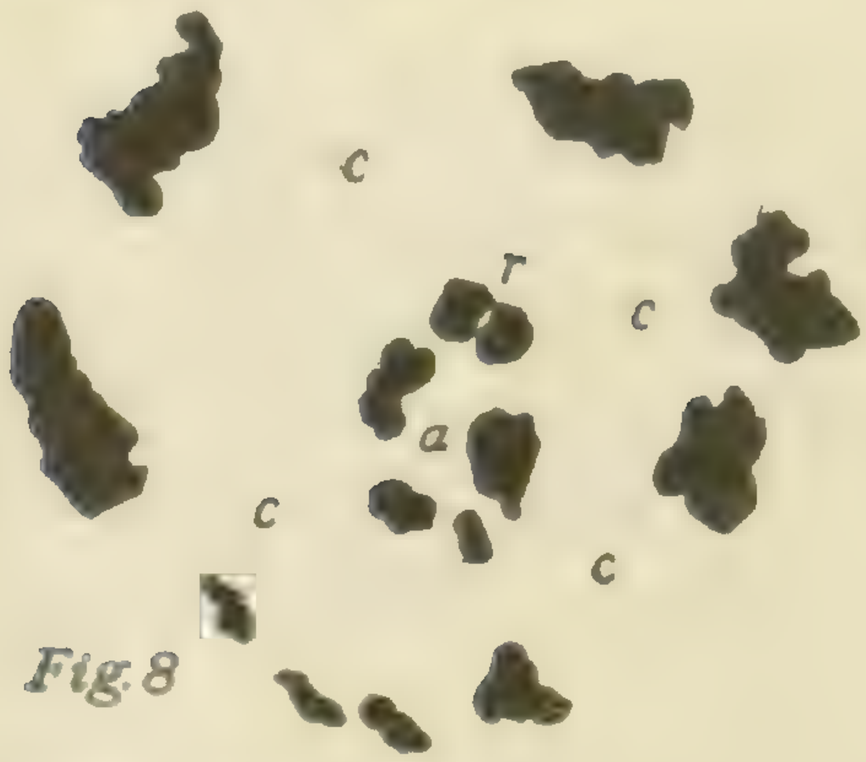

Fig. 8

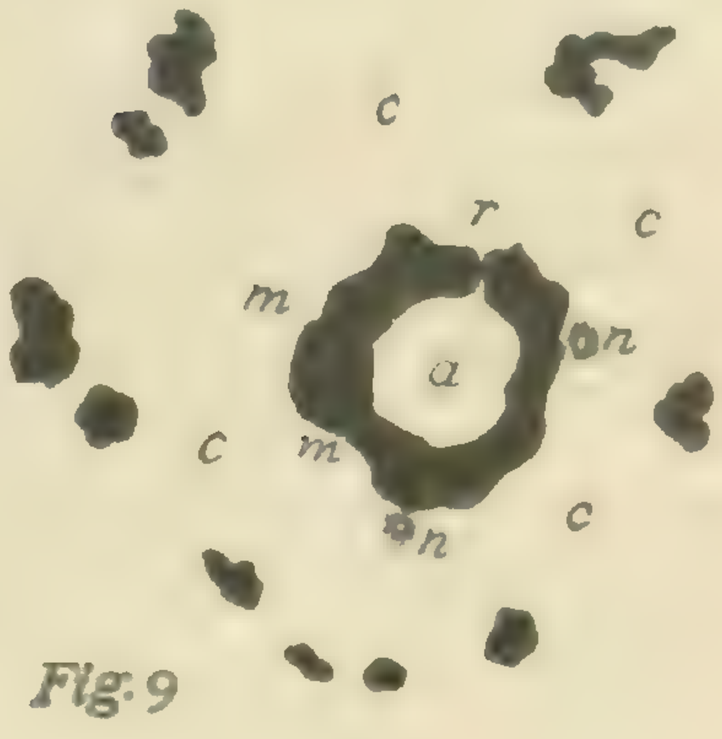

Fig. 9

FIGS. 4–9. — Nest of *Leptothorax emersoni* n. sp., within the nest of *Myrmica scabrinodis* Nyl.

down comfortably and appeared to experience all the sensuous satisfaction of a couple of jaded roués who have dropped into a Turkish bath for the night. The naturalist of a past generation would probably have interpreted the behavior of Leptothorax

under these circumstances as a politic act of hospitality on the part of a defenseless but intelligent creature. To-day there would be little hesitation in interpreting it as merely a machine-like reflex called into activity by its customary stimulus, the presence of the Myrmicas. That the truth lies somewhere between these two conceptions, though possibly nearer that of reflex than of intelligent action, was apparent from the subsequent behavior of the Leptothorax. These ants undoubtedly had some dim desire to remove the Myrmicas from their nest, for from time to time a Leptothorax was seen to pull with her mandibles at the fore leg or antenna of one of the intruders, as if to remind her that there are limits to polite hospitality. This action was never performed by the Leptothorax while foraging in the Myrmica galleries, but it was regularly performed whenever, as on this and several subsequent occasions, any Myrmica broke into the central chamber. The direction of the tugging was not very definite or constant. Often when a Myrmica thrust its head through the wall, the tugging was indeed towards the interior of the chamber, as if to draw the intruder in. But as the small ant was not able to move the large Myrmica, and as it could not under the circumstances tug in any other direction, the action could hardly be regarded as anything more than a gentle means of persuading the Myrmica to leave. This tugging was the only act even approaching hostility witnessed between the two species. The Myrmicas never showed the slightest irritation towards the Leptothorax, never seized them in their mandibles, nor even menaced them. They seemed rather to look upon the little creatures with gentle benevolence, much as human adults regard little children. They never passed their little guests without the antennal greeting, and the Leptothorax shampooed their hosts with comical zeal.

The two Myrmica workers whose intrusion into the Leptothorax chamber led to the above observations finally departed, only to give a second party of Myrmicas an opportunity to make a large breach in the wall at *xx*. These entered the chamber at 1.20 P.M. and were received in the same gracious manner as the first party, and in turn departed after being as

politely requested to leave. The Leptothorax then at once set to work to repair their dilapidated wall. At 1.30 a worker went out into the adjoining gallery, picked up a pellet of earth and placed it in the breach. Again and again she returned and gathered earth, often going to a distance of one or two inches from the chamber for suitable pellets. Another worker soon began to assist in repairing the breach from the inside, taking the pellets for this purpose from the inner wall of the chamber. Then the first worker walked around the nest, entered it through the passageway at *r* and began to clean herself, while a third worker went out through the breach and continued the work on the outside till the wall was completed. This was accomplished by 3 P.M.

At 4 P.M. a little water was poured under a corner of the glass where the Myrmicas had congregated in greatest numbers. This additional moisture induced them to move *mit Kind und Kegel* to the middle of the nest. Here they soon began to break through the walls of the Leptothorax cell in two places (Fig. 6 *s s*). Two Myrmicas again settled down in the cell and underwent the usual shampooing. As soon as they had departed the little ants again set about repairing the walls as before. Sometimes three or four of them worked at the same breach. During the progress of the work they frequently went from two to three inches into the Myrmica galleries in search of the requisite earth. At the same time a few workers toiled from the inside of the cell, and these were soon joined by the queen, working as busily as any of her progeny.[1] Occasionally a worker, after building for some time on the outside, would slip through the breach, turn around and build from the inside. Twice Myrmicas rushed up to the spot *s* (on the right side in Fig. 6) and commenced tearing down the wall. They easily took out pieces of earth eight or ten times as large as those which the little Leptothorax workers were putting in with so much care and difficulty. But the infraction of the Myrmicas did not escape the attention of the Leptothorax. They

[1] It is interesting to note in this connection that Forel ('**74**, pp. 339–341) long ago observed that the queens of the European species of Leptothorax (*L. acervorum* and *tubero-affinis*) do not shirk their share of the menial labors of the nest.

interrupted their repairs to shampoo and kiss the interlopers and again they tugged them by a leg or an antenna, sometimes in one direction, sometimes in another. And again I was forced to conclude that the Leptothorax workers wished to dissuade their big hosts from trespassing on their property. At any rate, the Myrmicas changed their plans and retreated to another part of the nest, just as the other parties had done on former occasions. The Leptothorax then continued their repairs. By 6 P.M. the walls had been rebuilt and the cell had the appearance of Fig. 7. The original entrance, *r*, had been much narrowed so as to exclude all but the slender-bodied inhabitants of the chamber.

At 7 o'clock on the following morning (August 28) the Leptothorax nest was found in *statu quo*, except that the queen had laid three more eggs during the night. By noon, however, the Myrmicas had again broken into the cell, so that at 4.30 P.M. the wall was torn down in several places. Nevertheless, the ever alert guest ants had piled up the earth so that the Myrmicas could scarcely squeeze between it and the glass roof-pane. The inroads of the Myrmicas had been so extensive, however, that even as late as 7 P.M. the nest presented the appearance of Fig. 8.

By 7 A.M. on the following day (August 29) the nest had been almost entirely rebuilt, as shown in Fig. 9. The Leptothorax must have labored during a large portion of the night. They had remodeled the nest, giving it a circular form, whilst apparently retaining the old opening at *r*. Besides this opening they had two others at *n n*, which were underground passages. The ants could be seen diving into these and anon reappearing within the circular chamber, the bottom of which had been sunk still deeper in the soil. The neat little nest now contained ten eggs. From day to day the Myrmicas had been widening their galleries, as is readily seen by comparison of Figs. 4 to 9, so that only small pillars of earth remained to support the roof-pane around the Leptothorax cell.

On succeeding days essentially the same conditions as those above described were repeated with slight differences in detail. For the sake of completing the history of the double nest, the

observations extending from August 30 to September 4 are condensed in the following notes :

August 30. The round cell, which remained undisturbed all day yesterday, was still intact at 8 o'clock this morning. By noon, however, the Myrmicas had torn down its wall in several places, and three of them were found in the cell, submitting to a vigorous shampoo. By 8 o'clock in the evening the circular nest had been rebuilt. The opening at *r* had been closed and a new one opened at *m* (upper left-hand corner of cell in Fig. 9).

August 31. Almost an exact repetition of yesterday's performance.

September 1. This morning the reconstructed Leptothorax cell is smaller. Its upper entrance, *m*, and the two subterranean entrances, *n n*, have not been changed. The ants have sunk the pupæ and eggs to a greater depth in the earthen floor of the nest, so that they are almost in contact with the board. The nest was not molested by the Myrmicas during the day.

September 2. The cell this morning has further decreased in size but is still intact. Its cavity is not more than 7 mm. in diameter, so that the Leptothorax family is much crowded. The two subterranean entrances at *n n* are still in use but the upper entrance has been shifted to *m* (lower left-hand corner of cell in Fig. 9). The Myrmicas still leave the cell unmolested.

September 3. To-day, too, the Leptothorax were left in peaceful possession of their cell. Many of them went out into the galleries from time to time to shampoo the Myrmicas and solicit food, which they then distributed to their queen and to the few workers remaining at home. During the day the upper entrance at *m* was closed so that the wall of the nest was everywhere in close contact with the roof-pane. The ants still entered and left the chamber through the two underground entrances at *n n*.

September 4. At 8 A.M. the Leptothorax nest was unchanged, but by noon its circular walls had grown perceptibly thinner, as the Myrmica workers had again taken to removing the earth from the outer surfaces. The nest was now shaped like a volcano with sloping sides and the guest ants inhabiting the crater. By 5 P.M. the Myrmicas had made two breaches in the walls. The nest remained in this condition throughout the evening.

The rhythmical assaults of the Myrmicas on the Leptothorax retreat in the afternoon, on several of the days during which the ants were observed, is, I believe, to be explained as the result of rising temperature. In the Litchfield Hills the nights and mornings of late August and early September are rather cool, while the noon hours may be very warm. The Lubbock nest happened to be placed at a window in a room with south-western exposure, so that the diurnal variation in temperature must have been keenly perceived by the ants. In the warm afternoons the activities of the Myrmicas increased; they ran about more rapidly, became more enterprising, and indulged their excavating instincts to a greater extent. Then in the course of this employment they often broke into the Lepto-thorax retreat.

The fact that the Leptothorax changed their entrances from time to time, and, as shown by the figures, kept perfecting the form of their cell, thereby making it easier to guard and rebuild and more difficult for the Myrmicas to demolish, is evidence of the remarkable psychic plasticity of these ants. Similar behavior on the part of ants that have been repeatedly disturbed by other species are recorded by different observers. Forel ('**94**, p. 8) brought a large formicary of *Myrmicocystus altisquamis* from Algiers and gave it an opportunity to establish itself in a garden near Zürich. The African ants were much annoyed by the incursions of *Lasius niger* and *Tetramorium cæspitum*, and although they at first adhered to their Algerian custom of maintaining a large open entrance to their nest, they learned during the course of the summer to narrow the opening gradually. Finally they plugged it up completely with grains of earth and made only a small temporary orifice whenever they strolled out on sunny days. Wasmann ('**97**, pp. 69, 70) mentions a nest of *Formica sanguinea* that resorted to a similar method of protecting itself from the repeated attacks of a neighboring colony of *F. pratensis*. All these observations go to show that Bethe's conception ('**98**; '**00**) of ants as *mere* "reflex machines" cannot be entertained.

From the persistent and strenuous efforts of the Leptothorax to intrench themselves, and from the shape and character of

their chamber and its entrances, we are justified in concluding that these little guest ants must be in the habit of constructing similar lodgings for themselves in the midst of the natural nests of the Myrmica. In their natural environment the Leptothorax would not be cramped for space as they were in the artificial nest, and they would probably dig their cell where they would not be so frequently disturbed by their inquisitive hosts.

While making the observations above recorded I was much impressed with the poverty-stricken appearance of the Myrmica colony. Although it originally contained no less then six fertile queens, the number of workers, larvæ, pupæ, and eggs was disproportionately small. Furthermore, many of the workers were of rather diminutive size, and a few of them had crippled abdomens. I began to suspect that the Leptothorax might be appropriating the liquid food regurgitated by the Myrmica workers on the mouths of their larvæ. With this in mind I closely watched the larvæ and the inquiline ants. Once I saw a Leptothorax lick the mouths of two young larvæ that were lying side by side, and on another occasion a Leptothorax licked the body of one of the larvæ. But finally, on September 3, I made an observation which convinced me that the regurgitated food is not stolen from the mouths of the Myrmica larvæ. On the morning of that day four Myrmica workers were found tugging at the head of a large larva. Under the lens I could see that a mass of regurgitated syrup had hardened over the face of the larva like a mask, and that the four workers were trying to remove it. At last one of them succeeded in pulling it off, and while she was moving away with it the mass stuck to the roof-pane for a moment, and I could see that it was quite hard and glutinous and must have remained on the face of the larva for some time. As the Leptothorax were continually roving about the galleries in search of food, they could hardly have failed to appropriate so rich a morsel if they were in the habit of obtaining their food in this manner. If any conclusion can be drawn from the single nest to which my observations have been confined, it would seem to be that the poverty-stricken condition of the Myrmicas, notwithstanding the number of fertile queens, must be brought

about more indirectly by the Leptothorax, *viz.*, by their continually pestering the Myrmicas for food and thus diverting to their own use much of the sustenance that would, under other conditions, benefit the Myrmicas themselves and their progeny.

If I have correctly estimated the influences which may tend to diminish the fecundity and prosperity of the Myrmicas we have in this double nest another striking demonstration of the complete absence in ants of any faculty of reason. For, if the Myrmicas possessed a glimmer of this faculty, they could easily annihilate the gluttonous little nest mates that are forever roaming about their galleries like so many animated stomach pumps.

As I was obliged to leave Colebrook I took advantage of the cold morning of September 5, when the ants were inactive, to transfer them all to a Cohansy jar containing some earth. From this date till October 1 I was traveling about and was therefore compelled to suspend observations on the compound nest. On returning to Austin, Texas, October 1, the ants were again transferred to a Lubbock nest, but to my dismay I found only the queen and a single worker of the Leptothorax remaining. The eggs, the two male pupæ, and the other workers of this ant, together with nearly all the larvæ and pupæ of the Myrmica, had disappeared. The Leptothorax queen was very uneasy and wandered about outside the Myrmica nest. On the following day she disappeared. She had probably contrived to cross the moat on the bodies of some drowned Myrmicas.

The single worker remained in the nest and for several days ran about shampooing the Myrmicas and soliciting food. On October 7 she, too, escaped from the nest and was found struggling in the moat. She was rescued from drowning and soon recovered sufficiently to crawl into the nest, though she showed no desire to mingle with the Myrmicas. Finally she lay motionless in a deserted gallery, where she was found dead the next morning. Thus ended the last of these fascinating little ants.

(*To be continued.*)

THE LOUISIANA DEER.

GLOVER M. ALLEN.

It has long been known, in a general way, that the deer inhabiting the lowlands of Louisiana is distinctly different from the related races to the north and east. As long ago as 1820, Geoffroy Saint-Hilaire and Cuvier[1] figured a doe in summer pelage under the name of "Biche du Cerf de la Louisiane." They did not, however, consider it different from their "*Cervus virginianus*" (= *Odocœlus virginianus virginianus* Bodd.[2]).

Through the kindness of the museum authorities, I have been enabled to examine the series of deer skins and skulls in the Museum of Comparative Zoölogy. In the Bangs collection are four skins and skulls of deer from Mer Rouge, Louisiana. These represent a well-marked race, which may be known as

Odocœlus virginianus louisianæ, subsp. nov.

Type: No. 9111, collection of E. A. and O. Bangs, in Museum of Comparative Zoölogy. Adult male, from Mer Rouge, Morehouse County, Louisiana. Collected Nov. 8, 1898, by B. V. Lilly.

General characters: Size large; color, in winter, pale; skull long and slender; lower row of molar teeth long; antlers heavy and high.

Color of type—body: dorsal surface from between the eyes to the root of the tail a grizzled cream-buff and brownish-black;

[1] *Histoire Naturelle des Mammifères*, etc., tome i, livr. xvii, Paris, 1824.

[2] As pointed out by Dr. J. A. Allen in the *American Naturalist*, vol. xxxiv. No. 400, p. 318 (April, 1900), Erxleben did not propose the name *americanus* for the Virginia deer in his sentence, "Differtne vere *americanus* uti Pennanto videtur": '*americanus*' is here a mere adjective and not a tenable name, since such names are given in the margin. Erxleben here merely mentions the American form, giving a description and synonymy without himself passing judgment on its validity as a distinct species.

each hair has a fine black tip, below which it enlarges slightly in diameter and presents a zone of cream-buff, then one of brownish-black, which shades into whitish near the root. Passing ventrally from the back to the sides, this whitish base gradually becomes more extensive, to the final exclusion of the brownish-black zone, so that the sides of the belly are a nearly uniform cream-buff to ochraceous-buff. On the lower part of the shoulders the color of the back shades into a grizzled grayish. The tail above is nearly unicolor with the back and has a few pale rufous hairs at its base; the terminal third is nearly uniform black. The ventral surfaces of the body and tail are white. The chest is ochraceous-buff, with a slight intermixture of long brownish-black hairs between the forelegs.

Head and neck: A small area behind and between the nostrils and a semicircular patch ventrally on each side of the angle of the jaw, brownish-black. Chin, upper throat, eye-ring, and sides of the muzzle whitish; a few black bristles about the eyes. The rest of the sides of the head are a finely grizzled white and brownish-black, passing into the white of the chin and the bright cream-buff of the throat. The ears on their outer surfaces are similar in color to the top of the head and have the edges of the tips brownish-black; their inner surface is lined with long, delicate white hairs.

Limbs: The inner surfaces of the axillæ and thighs are white; the color of the outer surfaces passes from the color of the sides of the body proximally, to an ochraceous-buff distally. A line of white hairs is present between the toes. The metatarsal gland is small, 14 mm. in length, and is surrounded by stiff, short white hairs, forming a tuft which has a concealed outer border of brownish-black. The hoofs and dew-claws are as long as in the type of *Odocœlus virginianus borealis* (Miller),[1] but slightly narrower.

The three other topotypes (Nos. 9112, 8622, 8623, Bangs collection) agree closely with the type in coloration, but No. 8623 has a darker median dorsal line, and the upper surface of the tail is uniformly black save for a few rufous

[1] *Odocœlus americanus borealis* Miller, *Bull. N. Y. State Mus.*, vol. viii, No. 38 (October, 1900), p. 83.

hairs near the base; in No. 9112, as compared with the type specimen, the tail is more rufous, with a short black tip.

I have not seen specimens of this deer in the summer pelage, but the doe in summer coat figured by Saint-Hilaire and Cuvier is bright reddish, and as the nearest races to the east and west are brighter in summer than in winter, a seasonal change of similar nature may be looked for in the Louisiana deer.

The skull: The skull of the Louisiana deer is long and slender. The nasals are long and narrow; the zygomatic and

FIG. 1.—Skull of *Odocœlus virginianus borealis* (Miller), ♂, type No. 4999, Coll. E. A. and O. Bangs, Mus. Comp. Zoöl.

the palatal breadths are narrow, being much less than those of the northern Virginia deer (*Odocœlus virginianus borealis*). In the type of *O. louisianæ* the distal end of the nasal bone touches the proximal end of the premaxillary, and the same is true in the skull of No. 8623, ♂, topotype. In this respect there is a resemblance to *Odocœlus virginianus osceola* (Bangs)[1] and *Odocœlus texanus* (Mearns).[2] However, in No. 9112, ♂, topotype, an upward projection of the maxillary separates these two

[1] *Ciriacus osceola* Bangs, *Proc. Biol. Soc. Wash.*, vol. x (February, 1896), pp. 25–28.
[2] *Dorcelaphus texanus* Mearns, *ibid.*, vol. xii (Jan. 27, 1898), pp. 23–26.

bones for a space of about 3 mm.; while No. 8622, also ♂, topotype, resembles the northern Virginia deer in that this arm of the maxillary separates the nasal and premaxillary bones by a larger space, in this case 15.5 mm. The lower molar row is long, being even a trifle longer than in *O. borealis*, though the jaw of the latter slightly exceeds that of *O. louisianæ* in length. In all the specimens examined the ramus of the jaw shows a slight concavity in ventral outline between the molar region and the tip, resembling in this respect *O. osceola* and differing from

FIG. 2.—Skull of *Odocœlus virginianus osceola* (Bangs), ♂, No. 2391, Coll. E. A. and O. Bangs, Mus. Comp. Zoöl.

O. borealis, in which the ventral outline of the jaw is more nearly straight. Following are some measurements in millimeters of the skull of the type of *O. louisianæ*, and by way of comparison the corresponding measurements of the type of *O. borealis* (No. 4999, ♂, Bangs collection), the race most resembling it in size, are given in parenthesis after each. (Unfortunately, the occipital region has been sawed off from the Louisiana skulls by the collector, but there seems to be no appreciable difference in length between them and northern Virginia deer skulls.) Zygomatic breadth, 115 (130); least inter-orbital breadth, 69 (80.5); greatest length of nasals,

106 (95); greatest breadth of nasals, 19 (21.5); length of premaxillary, 81 (86); greatest palatal breadth between upper molar rows, 45.3 (55); extreme length of lower molar row, 84 (82).

Antlers: The antlers of the Louisiana deer are heavy, and equal in size those of the northern Virginia deer, but as compared with them they arise from the head at a sharper angle

FIG. 3. — Skull of *Odocœlus virginianus louisianæ*, ♂, type No. 9111, Coll. E. A. and O. Bangs, Mus. Comp. Zool.

and bend strongly inward, so that, although the length of beam is practically the same in the type specimens of *O. louisianæ* and *O. borealis*, the antlers of the former are higher and at the same time 80 mm. less in width across the beams than those of the latter. In these high, narrow antlers there lies another point of resemblance between the Louisiana deer and the little Florida deer. The antlers of the type specimen of *O. louisianæ* measure 566 mm. from the burr to the tip of the beam, following

the inner curves of the latter. The circumference of the antler at the base just above the burr is 119 mm. In addition to the basal prong (that of the right antler being single and that of the left bearing a small additional point on its anterior face), there are on each beam three large tines and a small point on the inner side of the beam between the first two tines. The second tine is, on each antler, the longest. Both of these tines possess an extra point on the anterior face near the tip, and that of the left antler has also one on its outer face.[1]

Size: The specimens from Louisiana are unaccompanied by measurements, so that the following taken from the dry skins can only be considered approximate. The measurements of the four specimens are given in millimeters in order thus,— Nos. 9111 type, 9112, 8622, 8623: length from nose to end of tail (exclusive of terminal hairs), 2072, 1995, 1856, 1695; tail, 220, 253, 285, 240; hind foot, 490, 393, 375, 382; ear from crown, —, 122, 130.5, 134.5. No. 9112 is a young three-point buck captured Dec. 10, 1898; No. 8623 is a spike buck, and with No. 8622, a one-point buck, was taken March 4, 1899.

Range: The lowlands of Louisiana, perhaps found throughout most of the Austro-riparian zone.

Remarks: The Louisiana deer is more closely related to the little Florida deer (*Odocœlus virginianus osceola*) than to the more northern races. Indeed, it is in general appearance but a larger and slightly paler representative of that animal. To the west of its range is another small deer, *Odocœlus texanus* (Mearns), but, as Dr. Mearns himself states, it is not to be confounded with the Louisiana deer. From true *Odocœlus virginianus* (Bodd.), the large size and proportions of *O. louisianæ* are alone sufficient to distinguish it, while from *Odocœlus virginianus borealis*, which it equals in size, it is easily separated by the cranial and color characters here given.

[1] In the accompanying photographs the skulls were all placed at the same distance from the lens of the camera without changing its position or focus.

ON THE OSTEOLOGY AND SYSTEMATIC POSITION OF THE SCREAMERS (PALAMEDEA: CHAUNA).

R. W. SHUFELDT.

Professor William Kitchen Parker was the first to suspect that those remarkable birds known as the screamers might in some way be related to the Anseres, and as long ago as 1863 he undertook to point out in his excellent paper on the subject in the *Proceedings of the Zoölogical Society of London* (pp. 511–518) what the relationships between the two groups consisted in. A few years later, however, Huxley included them among his Chenomorphæ (*op. cit.*, 1867, pp. 436–460). Naturally such authorities carried great weight for some time, but when Garrod came to investigate the structure of *Chauna derbiana* he quickly arrived at the conclusion that the Palamedeidæ were surely no geese, whatever the affinity might be between the two groups (*P. Z. S.*, 1876, pp. 189–200). Dr. Sclater in 1880 created a distinct order for them (Palamedeæ), still keeping them, however, in the neighborhood of the Anseres. Dr. Stejneger includes them with the Chenomorphæ as a super-family (Anhimoideæ), as I have elsewhere pointed out, while Dr. Fürbringer makes an intermediate suborder for them standing between the anserine birds and the family Æpyornithidæ. Mr. Seebohm kept the flamingoes, Anseres, and the Palamedeæ as suborders in the order Lamellirostres; and Sharpe places only the Anseres and the screamers in an order Anseriformes. Professor Beddard (*P. Z. S.*, 1894) makes comparisons between Palamedea and Chauna, but expresses no decided opinion there as to the systematic position of the group.

Of all the accounts I have read of the osteology and taxonomy of the screamers, none come so near to what I consider to be the truth in the case as does the above-cited contribution

EXPLANATION OF PLATE.

Right lateral view of the skeleton of the horned screamer (*Palamedea cornuta*). Greatly reduced. Photograph of specimen No. 18,588 of the Osteological Collections of the U. S. National Museum. (Collected in Venezuela.)

of Garrod's in the *P. Z. S.* of 1876. His figures illustrating his remarks are extremely instructive, comparing as he does the occipital aspects of the skull of a Magellaine goose (*Chaphaga magellanica*), a Derbian screamer (*Chauna derbiana*), and a razor-billed curassow (*Mitua tuberosa*). He also gives the basal view of the skull of *Chauna derbiana*. Garrod draws some very careful comparisons among the several forms just named, and it is well worth the pains of the student of avian osteology and classification to read what he has to say, in the paper cited, in connection with the present contribution.

With the view of throwing additional light upon the affinities of the screamers, I have compared the skeleton of the horned screamer, *Palamedea cornuta* (see plate, opposite page), with that of the Coscoroba swan (*Coscoroba coscoroba*) and the common wild turkey (*Meleagris gallopavo*) and arranged the principal osteological characters characteristic of each form in the subjoined table in a comparative way, thus supplementing the results already achieved by Garrod and further emphasizing some of the opinions arrived at by him in regard to the systematic position of the screamers.

SKULL.	SCREAMER.	SWAN.	TURKEY.
General aspect.	Conspicuously galline.	Typically anserine.	Typically galline.
Superior mandible; vault of orbit and cranium; occipital area.	Characteristically galline.	As in other Anseres and quite different.	Agrees almost exactly with the screamer: galline.
Lacrymal bone.	Very small, but anserine.	Very large, with superior portion elongated.	As in the fowls generally, and very different.
Interorbital septum.	Entire.	Entire.	Perforated.
Quadrates.	Ansero-galline.	Anserine.	Galline.
Auricular opening.	Galline.	Anserine.	Galline.
Lateral processes of the cranium.	Anserine.	Anserine.	Fuse distally, and thus include a foramen.
Palate.	Desmognathous.	Desmognathous.	Schizognathous.

SKULL.	SCREAMER.	SWAN.	TURKEY.
Palatines and Vomer.	Galli-anserine, or with characters nearly equally divided.	Anserine.	Galline.
Facets of pterygoids.	Median, as in many pigeons.	Anterior.	Anterior.
Basi-temporal area.	Subtypically galline.	As in other swans and geese.	As in most true fowls.
Mandible.	Strongly galline, but with the angular processes approaching the Anseres in character.	As in other typical lamellirostral birds, and very different from Palamedea and the fowls.	Characteristically galline.
Hyoidean apparatus.	Galline.	As in the Anseres generally, and very different from Palamedea.	Galline.
VERTEBRAL COLUMN.			
Cervicals.	18. Pair of free ribs on last.	21. Two last bearing free ribs, with epipleural appendages on last pair.	16. As in the swan, but the last cervical *fused* with the first dorsal vertebra.
Ribs.	Six pairs vertebral ribs; *all without* epipleural appendages. Two pairs pelvic ribs; costal ribs of last pair do not reach the sternum.	Five pairs vertebral ribs; *all with* epipleural appendages. Three pairs pelvic ribs; costal ribs of last pair do not reach the sternum.	Four pairs vertebral ribs; *all with* epipleural appendages. One pair pelvic ribs; costal ribs of last pair do not reach the sternum.
[No epipleural appendages on the Pelvis.	Narrow and longish, but on the whole with quite as many galline characters as anserine. Propubic processes absent. Distal ends of pubic elements *not* dilated.	pelvic ribs in any Narrow and long. Propubic processes present. Distal ends of pubic elements greatly dilated.	of these birds.] Shorter, and broad in postacetabular region. Quite different from swan and screamer, but with propubic processes present, and distal ends of pubic elements *not* dilated.

VERTEBRAL COLUMN.	SCREAMER.	SWAN.	TURKEY.
Shoulder-girdle.	Anserine character decidedly prevailing. Os furculum U-shaped, with the arch very broad transversely and antero-posteriorly flattened; articulation with coracoids and scapulæ as in the geese. Coracoids more anserine than galline.	Os furculum U-shaped and typically anserine. As in the screamer, the coracoids do not come in contact when articulated *in situ*.	Os furculum V-shaped, and the elements of the shoulder-girdle all typically galline.
Sternum.	Anserine characters prevailing; but the posterior pair of notches shallower, and the lateral xiphoidal processes far broader.	Agrees with all the typical anserine fowls among the swans, geese, and some of the ducks.	Completely galline in character, and very different from the sternum of Palamedea.
Limbs.	*Highly* pneumatic.	Humerus only pneumatic (?)	Humerus pneumatic; femur partially so (?)
	Proportions and characters of pectoral limb, as compared with Meleagris, decidedly anserine. Large spurcores fused on carpometacarpus (upper one three times the size of distal one). Small ungual claws on pollex and index digits.	Bones of pectoral limb long and light, as in most large anserine birds.	Bones of pectoral limb are proportionately as well as actually considerably shorter and slightly stouter. Typically galline, with no special agreement with the corresponding ones in the wing of Palamedea.

VERTEBRAL COLUMN.	SCREAMER.	SWAN.	TURKEY.
Limbs.	Pelvic limb anserine, with long podal digits. Cnemial processes of tibio-tarsus not as prominent as in the swans and fowls.	Hypotarsus of tarso-metatarsus somewhat like that of the screamer.	Hypotarsus very different from that process in Palamedea.

From an osteological point of view the screamers are extremely puzzling forms. Had we only the skull of *Palamedea cornuta* to judge from, there is no question but that avian taxonomers would have placed that species close to the gallinaceous group of birds, its desmognathous palate notwithstanding. We obtain but little light on the subject by the comparisons made of its vertebral column and pelvis, though in the latter we meet with some characters that seem to suggest an affinity with the storks.

Had we but its shoulder-girdle and sternum to judge from, it is quite questionable in my mind that from these bones alone its anserine affinities, or such as it may possess, would have been suspected, and it is only when the characters of these are taken in connection with others now known to us, that such a belief gains support. We should never suspect Palamedea of having any kinship with the Anseres were we to judge from the skeleton of its wing alone, though it is very likely that such a relation would have been suspected had we only the bones of the pelvic extremities to guide us.

Taken as a whole, the anserine characters of the skeleton of Palamedea, however, are more evident than those of any other group of the class, but these characters are neither typical nor are they strongly marked. Such galline characters as are exhibited in its skeleton are far more typical and most decidedly more evident. But neither its anserine nor its galline osteological characters are sufficiently pronounced to justify us in arranging the screamers either along with the Anseres or the

gallinaceous fowls. Such other characters as it may have in its skeleton, derived from ancestral representatives of still other groups, are now too completely masked and too obscure for us to decipher, especially as all of the near relatives of these birds have long ago died out, leaving no existing forms to assist us in the matter. Palamedea, then, is doubtless the survivor of an extremely ancient stock of birds, and were it positively known that the gallinaceous types and the Anseres sprang from a common stock, and it is not at all impossible, such birds as the screamers may have easily appeared close down at the branching and then have ascended to the present time, showing but few structural changes in their organizations.

Palamedea is a strong, vigorous, and eminently combative type of fowl, and one not calculated, in time, to have been much modified by its surroundings, and so has preserved in its morphology the major share of its archaic structure.

I agree with Fürbringer that the screamers should be placed near the Anseres, but apart and in an independent group, standing between the latter and the ostrich types of birds.

The Palamedeæ, in fact, constitute a suborder of birds (although represented but by three existing species) coequal in the matter of distinctness with a number of others that have been created in the class Aves, and, as a group, even better defined and more distinct than not a few others. It is fortunate for us indeed that in their anatomical structure there is *so* much that enables us to recognize as clearly as we can the place occupied in the system and in the class by these birds and to predict with such certainty what their relationships are with the other main groups of avian forms.

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NORMAL RESPIRATION AND INTRAMOLECULAR RESPIRATION.

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"RESPIRATION is essentially the intake of oxygen and the output of carbon-dioxide by living cells. In the higher animals two phases of respiration are distinguished — the *external*, the exchange of gases between the air or water and the blood; and the *internal*, the exchange between the blood, lymph, and the tissues." [1] In plants there is, for the most part at least, only the one phase, the exchange of gases between the air or water and the cells composing the tissues, an exchange which is direct and "external," since it takes place in most cases between the air, whether in the intercellular spaces within the plant, or unconfined and outside the plant body, and the individual cells. Even in the densest tissues, within which the intercellular spaces are small, it is likely that the cells take in free oxygen and give out carbon-dioxide, if not directly from intercellular spaces, then from their neighbors bordering on intercellular spaces. In any case, and in every stage of the process of respiration except the purely mechanical ones, of which only the higher animals are capable, the exchange of gases between the cells and the air takes place in solutions, the oxygen entering and diffusing through, the carbon-dioxide passing out from, the cells only when these gases are dissolved in water.

The object of respiration in plants is not the maintenance of a certain body temperature, together with the production of energy needed for doing work, as in warm-blooded animals. It is merely the production of energy for doing work, as in cold-blooded animals. The average body temperature of plants is, in general, nearly the mean daily temperature of their environment. It will vary within certain limits, the variation being

[1] Pembry, M. S. Chemistry of Respiration, Schäfer's *Text-Book of Physiology*, vol. i (1898), p. 692.

large or small according to the environment. Submersed aquatics will vary least, floating aquatics more, and terrestrial plants most in body temperature, other things being equal. But as the temperature of small, still bodies of water (pools, etc.) may vary considerably, so the body temperature of the organisms living therein will vary, being warmed by the sun and cooling during the night. The body temperature of the larger terrestrial plants is likely to be higher at night (except on the exposed surfaces), and lower in the day, than that of the surrounding air. Owing to the great extent of their surface as compared with their mass, radiation from the larger plants is rapid, and a body temperature independent of their environment could be maintained only at great expense of material laboriously collected and elaborated. Plants work economically, are compelled to do so, and this extravagance is avoided.

Heat is the form in which the energy set free by respiration usually makes itself evident, but it does not necessarily follow that only so much energy is liberated as is recognizable as heat, or that this is the only form in which energy is liberated. Only that energy becomes evident as such which is not at once used. In order to determine the amount of energy liberated in respiration, it is necessary to know and to measure the material products of respiration.

The substances ordinarily taking part and produced in the process of physiological oxidation are the highly complex nitrogenous and non-nitrogenous compounds elaborated by the organism and carbon-dioxide, water, and various small amounts of several other substances. Of these last, oxalic acid is the commonest and most important. Since the production of energy and not of any particular compounds is what is striven for in respiration, and since the substances acted upon by free oxygen are different in different plants and even in different cells of the same plants, the products differ accordingly.

Although the oxidation of nitrogenous matter also takes place, it is mainly the non-nitrogenous contents of the living cell which are involved in physiological oxidation. In the animal body the oxidation of organic nitrogenous compounds (proteids, etc.) results in the production of urea and of other

similar substances no longer usable and presently cast off from the body. In plants the elimination of these products is more economically accomplished, for they furnish the foundations for the re-synthesis of albuminous compounds. These waste substances are removed by transforming them synthetically into useful compounds.

The non-nitrogenous substances which become oxidized are the fats and oils, the starches and sugars. The oxidation may first convert the hydrocarbons into carbohydrates, with the liberation of energy and the formation of by-products, carbohydrates and by-products then becoming still further oxidized with the liberation of still more energy. While respiration is going on, the other functions also in operation may involve the use, with chemical change, of some of each substance produced in respiration, and the formation in the cell of other substances not the products of respiration at all. It is therefore evident that to ascertain the material products of respiration is hardly less difficult than to determine the amount of energy liberated. Since each process is normal only when accompanied by all the processes going on at the same time, it is impossible to isolate any physiological process for purposes of study. The products of one set of chemical activities in the living body may enter wholly or partially, simultaneously or successively, into other chemical activities. The end products can be recognized and measured with comparative ease, but to tell exactly where or how they are formed is much more difficult and not now entirely possible.

Water and carbon-dioxide gas are the chief products of the physiological, as also of all other forms of combustion of carbon-containing bodies. They are formed whenever a sufficient amount of oxygen is united with the higher carbon compounds. In organisms living under such conditions that the air can penetrate to all their parts, enough oxygen will always be present for such complete decomposition. The oxygen does not unite of itself with the combustible compound, for even if active (nascent) oxygen is present at all, which seems improbable,[1]

[1] Pfeffer, W. *Pflanzen-Physiologie*, 2te Auflage, Bd. i (1897), p. 554. *Physiology of Plants*, translated by Ewart, vol. i (1900), pp. 545, 546.

it is present in amounts insufficient to accomplish the whole result. The union is accomplished by and in the living cell; whether with a more readily oxidizable substance first formed from sugar, or with sugar itself, is not now known. All that is known is that sugar, or some similar substance, and oxygen unite, forming as end-products mainly carbon-dioxide and water. The following reaction, without indicating what, if any, intermediate stages there may be, shows the material results:

$$n((C_6H_{12}O_6) + 6\,O_2 + Aq.) = n(6\,CO_2 + 6\,H_2O + Aq.).$$

(*Aq.*, representing the water in which the sugar is dissolved in the cell, does not enter the reaction. *n* indicates the unknown multiple of the minimum proportional formula $C_6H_{12}O_6$, which stands for the sugar molecule. The $6\,H_2O$ produced in the course of combustion may unite with the solvent water (*Aq.*), or may pass off as vapor, diffusing the faster from the cell by reason of the heat liberated).

Since other substances than sugar are also oxidized physiologically in the cell, other products will be formed, the kinds and the quantities of the latter varying according to the former. The commoner of these minor products are oxalic, malic, and citric acids, which accumulate in considerable quantities in certain plants (*e.g.*, in the leaves of *Oxalis acetocella*, in the *Crassulaceæ*, in apples, etc., and in the citrous fruits, lemons, limes, oranges, etc.), or are converted into salts (*e.g.*, calcic oxalate, crystallizing out of the solutions in which it is formed in the cell), or undergo other changes (*e.g.*, further oxidation).

In all organisms the oxidation of nitrogenous compounds, as well as non-nitrogenous, occurs in normal respiration. The proportional amounts of the two groups of compounds physiologically oxidized vary with different organisms. In the majority only organic and highly complex compounds are made to yield the needed energy, but in some much simpler inorganic compounds suffice, and in a few organisms already known the carbon compounds are not used at all.

The nitro-bacteria, as first shown by Winogradsky,[1] oxidize

[1] Winogradsky, S. Recherches sur les organismes de la nitrification, *Annales de l'Inst. Pasteur*, tomes iv, v (1889–91), and other papers.

simpler nitrogen compounds in order to liberate energy, employing carbon compounds only in the synthesis of food to be used in the construction of their own bodies. One set of nitro-bacteria oxidize ammonia, or compounds of ammonia, to nitrous acid, the first and last steps of the process being thus indicated:

$$2\,NH_4OH + 3\,O_2 = 2\,HNO_2 + 4\,H_2O.$$

Another set oxidize the nitrous acid, or its salts, to nitric acid, thus:

$$2\,HNO_2 + O_2 = 2\,HNO_3.$$

The sulphur bacteria (*Beggiatoa*, *Chromatium*, etc.) obtain most if not all of their kinetic energy by oxidizing sulphur compounds. They precipitate sulphur in their own bodies by oxidizing the sulphureted hydrogen present in the water in which they live.[1] If the supply of gas remain sufficient, the sulphur will accumulate as a reserve supply in the cells; if it decrease, the reserve sulphur will be oxidized and, uniting with water, will form sulphuric acid, or its salts, thus:

$$2\,H_2S + O_2 = 2\,H_2O + S$$
$$S + O_2 = SO_2$$
$$2\,SO_2 + O_2 = 2\,SO_3$$
$$SO_3 + H_2O = H_2SO_4$$

Those bacteria (*e.g.*, Crenothrix) which, living in water rich in iron, deposit iron in some form in or upon their own bodies, may obtain their kinetic energy by physiologically oxidizing ferrous compounds, presumably ferrous oxide, to ferric oxide.[2]

Other bacteria may be discovered which, needing carbon and nitrogen compounds only to supply the constructive elements of protoplasm, obtain their needed energy by oxidizing other substances present in solution in the waters in which they live.

[1] Winogradsky, S. Ueber Schwefelbakterien, *Botan. Zeitung*, 1887. *Beiträge zur Morph. u. Physiol. der Bakterien.* Leipzig, 1888. Miyoshi, M. Studien über die Schwefelrasen-Bildung und die Schwefelbakterien der Thermen von Gumoto bei Nikko, *Journ. Coll. Sci. Imp. Univ. Tokyo*, Bd. x, pt. ii, 1897.

[2] Winogradsky, S. Ueber Eisenbakterien, *Botan. Zeitung*, 1888. Molisch, H. Die Pflanze in ihren Beziehungen zum Eisen. Jena, 1892. Miyoshi, M. Ueber das massenhafte Vorkommen von Eisenbakterien in den Thermen von Ikao, *Journ. Coll. Sci. Imp. Univ. Tokyo*, pt. ii, 1897.

The essential product of respiration, the one which distinguishes respiration from all the other functions of the living organism, is kinetic energy. The material products vary in kind and in quantity according to the nature of the organism and the substances which can be affected, these substances being in most cases complex compounds elaborated within the body of the respiring plant, but not in all cases, as shown by the bacteria just mentioned.

Nor is free oxygen necessary to all organisms or to all cells. As the hæmoglobin of the blood is a complex compound from which some of the oxygen, only loosely held, can be readily withdrawn where oxidation for the supply of energy is needed, so the color products of certain bacteria (*e.g.*, *Bacillus bruneus*) are reserves of oxygen which become used when there is no longer an adequate supply of free oxygen.[1] From colorless compounds also, the cells at depths in the tissues of animals (perhaps also of plants[2]), to which free oxygen penetrates only in insufficient amounts if at all, obtain by decomposition the energy needed. These decompositions are not necessarily effected to secure oxygen for the oxidation of other substances, for the decompositions themselves release as kinetic the potential energy which was holding the complex substances together.

The mutual attraction of one atom of carbon and two of oxygen is so great as to make the molecule of carbon-dioxide very stable as well as very simple, for the affinities of the carbon and oxygen are satisfied. In the complex compounds of carbon, hydrogen, and oxygen in the sugar group, the affinities of the component elements are not satisfied; the compounds are much less stable, as their ability to take up more oxygen shows. At ordinary temperatures and under ordinary conditions these compounds are stable. Their stability is due to the mutual affinities of their component atoms which exert an attraction upon one another sufficiently powerful to

[1] Ewart, A. J. On the Evolution of Oxygen from Colored Bacteria. *Journ. Linnean Soc.*, vol. xxxiii (1897), p. 123.

[2] Pfeffer, W. *Berichte d. math. phys. Klasse d. K. Sächs. Gesells. d. Wiss. zu Leipzig*, 27 Juli, 1896, p. 383.

hold them together in definite form. When the atoms are rearranged more compactly in simpler forms in space, their bonds or affinities are more completely satisfied, they unite more perfectly, oxidation takes place in the rearrangement, and energy is accordingly liberated and made available for other purposes. Energy is stored in the starch or oil or sugar molecule; the kinetic energy (solar or other) employed in the construction of the molecule remains in it as potential energy, holding the atoms together. The destruction of the molecule results in the liberation of so much kinetic energy as was employed in constructing it from the simple compounds worked upon.

The complete oxidation or combustion of a gram of dextrose (sugar), resulting in the formation of carbon-dioxide and water, as represented by this reaction,

$$C_6H_{12}O_6 + 6\,O_2 = 6\,CO_2 + 6\,H_2O,$$

liberates 3939 small or ordinary calories,[1] or mechanical units of energy in the form of heat.[2] For the sake of obtaining these figures in more exact terms, for use in future comparisons, we may multiply this with the molecular weight of dextrose, thus:

atomic weight of C = 12 — of C_6 = 72
of H = 1 — of H_{12} = 12
of O = 16 — of O_6 = 96

$C_6H_{12}O_6$ = 180 = molecular weight of dextrose.

3939 calories × 180 = 709020 calories
= 709.02 Calories

The heat of combustion or complete oxidation of 1 gram-molecule, *i.e.*, of 180 grams, of dextrose, is then 709.02 great calories (C.).

This reaction, and the production of this amount of heat, take place only in the presence of sufficient quantities of free oxygen. Molecules more complex than those of carbon-dioxide

[1] A calorie (c.) is the heat required to raise 1 gram of water 1° C. in temperature; a great calorie (C.) is the heat required to raise 1000 gr. (1 Kilo) of water 1° C.

[2] Rechenberg, C. von. Ueber die Verbrennungswärme organischer Verbindungen. *Inaug. Diss.* Leipzig, 1880. See also Pembry, M. L., on Animal Heat, Schäfer's *Text-Book of Physiology*, vol. i (1898). Here the literature is fully given.

and water, though simpler than sugar, may be formed from sugar without free oxygen or with free oxygen in smaller proportions than 6 : 1. Complete oxidation (normal respiration) yields the largest amount of energy possible ; less profound changes yield less energy. Thus the decomposition of sugar by yeasts, according to the following reaction, which represents only in simplest terms the nature of the chemical changes,

$$C_6H_{12}O_6 = 2\,C_2\,H_6\,O + 2\,CO_2,$$

forming without oxygen two molecules of alcohol and two of carbon-dioxide from one molecule of dextrose, yields only 67 calories per gram-molecule.[1]

The decomposition of one molecule of dextrose into one molecule of butyric acid, two of carbon-dioxide, and two of hydrogen, which is accomplished by a considerable number of species of bacteria, and may be represented by this reaction,

$$C_6H_{12}O_6 = C_4\,H_8\,O_2 + 2\,CO_2 + 2\,H_2,$$

yields about 75 calories per gram-molecule.[2]

Bacteria forming acetic acid, acting on dilute solutions of ethyl alcohol in the presence of free oxygen, partially oxidize the alcohol and decompose it into acetic acid and water, thus :

$$C_2H_6O + O_2 = C_2\,H_4\,O_2 + H_2O,$$

liberating 125 calories ;[3] but if the alcohol were completely oxidized, as in ordinary combustion, the reaction would be

$$C_2H_6O + 3\,O_2 = 2\,CO_2 + 3\,H_2O,$$

and the heat liberated would be nearly three times as much, about 325 calories per gram-molecule.

In these figures we have indices of the relative values of complete and incomplete oxidations, and of oxidations and decompositions, as sources of energy in the form of heat. These figures are indices, to be trusted only so far as relative, not exactly proportional, values are concerned. The chemist can control all the conditions under which he makes a

[1] Rechenberg, *loc. cit.*, p. 66.

[2] Rechenberg, *loc. cit.*, p. 67.

[3] Quoted from Berthelot in Biedermann's Chemiker-Kalender for 1897, p. 193 of the Beilage.

combustion in his laboratory and determines the number of heat units liberated; he can so regulate the process that there shall be no by-products, and that no other compounds are included in the reaction than those upon which he has determined to experiment. In the plant, on the contrary, other substances than dextrose may become oxidized, or the oxidation may be incomplete. In the laboratory one can deal with measured quantities of isolated substances; in the living organism indefinitely known quantities of many substances together are acted upon. Animal physiologists have done much more in this direction than have plant physiologists. The higher animals are better suited to such studies than are plants. The relatively high body-temperatures of warm-blooded animals permit direct temperature determinations from weighed quantities of known foods eaten, as well as calculations from the amounts of oxygen needed to effect combustions or decompositions. The animal physiologist can check the results obtained by one method with those reached through other methods. The results obtained by animal physiologists indicate that only about 95% of the calculated yield of energy from oxidation[1] appears as heat. So we must regard these figures as somewhat too high, but their suggestive value is great, whatever must be admitted as to their exact numerical value.

The larger organisms demand for the normal execution of their functions more energy than can be supplied by the rearrangement of the component atoms of the molecules always at hand. They must oxidize these molecules, and the more complete the oxidation, the greater the amount of energy liberated. Some of the smaller organisms supply themselves with adequate amounts of energy by the destruction of complex compounds within their own living cells. Probably some of the cells of all large multicellular organisms have recourse, at times at least, to the same means of securing needed energy, and when free oxygen is not obtainable, the majority of organisms can continue living for a time by so doing. From this the general inference may safely be drawn that the ability to obtain needed energy by the destruction of complex substances in the cells

[1] See Pembry in Schäfer's *Physiology*, vol. i, pp. 836, 837.

is inherent in all organisms, that in the majority of organisms and of their component cells this power is little needed and hence is practically undeveloped; but that, owing to the position of some cells deep in the tissues of many organisms and to the peculiar habits of some of the lowest organisms, these are obliged to obtain energy in this way and have developed their inherent power to a high degree.

Intramolecular respiration is the name given to this mode of respiration, a term not explicitly descriptive and therefore not entirely satisfactory. The German term *Spaltungsathmung* is in this regard more satisfactory, but it is not concisely translatable. Ordinary respiration is physiological oxidation or physiological combustion or aërobic respiration. It is dependent upon free oxygen and yields needed kinetic energy only by the union of free oxygen with combustible substances. Intramolecular respiration is physiological simplification of complex compounds or physiological rearrangement of atoms or anaërobic respiration. It takes place only when free oxygen is present in small quantity or is altogether absent. The results of the two processes are the same in kind — the liberation of the kinetic energy needed to continue living — but, as the figures quoted above show, not the same in degree.

Intramolecular respiration was first observed somewhat more than a hundred years ago by Rollo,[1] but only within the last few years has the connection between intramolecular and ordinary respiration been clearly demonstrated. Pasteur and other bacteriologists have contributed quite as much as animal and plant physiologists to our present knowledge of respiration. Pasteur and his followers have shown the peculiar habit of a large number of microörganisms of being active only when free oxygen is absent. When free oxygen is present, they are inactive, though they may remain alive. There is a chain of allied process: *first*, physiological respiration, or what may be called intramolecular respiration, the normal respiration of most organisms; *second*, physiological rearrangement of atoms into simpler molecules, intramolecular respiration, the mode of respiration to which many cells and even organisms

[1] Rollo. *Annales de Chimie*, t. 25, 1798.

have recourse under stress of circumstances; *third*, physiological rearrangement of atoms into simpler molecules, also intramolecular respiration, but the anaërobic normal respiration of a comparatively small number of invariably low organisms.

From experiments hitherto conducted, it would seem that the germinating seeds are better able to survive without a copious supply of oxygen than are the other parts of higher plants. This is what, *a priori*, might be expected, for the embryo in the seed, when it becomes active in germination, is a very vigorous organism, usually well supplied with just such foods as may be readily broken down into simpler compounds. The seeds of pea, for example, stimulated to germinate by being soaked for twelve to fifteen hours in water at room temperature, will continue to respire actively for forty-eight hours or more, even in a vacuum, producing carbon-dioxide in nearly the same quantity as under the same conditions of temperature, etc., in ordinary air. Of course some air containing free oxygen will be carried into the vacuum by the peas, but this will very soon be entirely exhausted in normal respiration. The continued supply of energy must be obtained by intramolecular respiration. Comparative investigations show that different plants and different organs vary considerably in their ability to substitute under stress intramolecular for normal respiration, and that in very few of the higher plants is intramolecular respiration, as measured by the yield in carbon-dioxide, so effective as normal respiration.

For all higher plants prolonged intramolecular respiration is impossible. To what this is due is not wholly clear. The substances first attacked in intramolecular respiration are the same as in normal respiration, *i.e.*, the sugars, starches (after conversion into sugar), and the fats and oils. Later the proteid substances enclosed in the cell, and finally the living substance itself, are decomposed to supply needed energy. Whether the cessation of intramolecular respiration in experiments upon higher plants, and the consequent death of the organism, are due to the destruction of part of the living substance, or to the production in the cells of poisonous substances, cannot now be determined. Certain it is that for

higher organisms intramolecular respiration is a function very limited in importance, taking place only when there is continued need of energy in the absence of free oxygen, and capable of being maintained for comparatively brief periods only. Like normal respiration, it is carried on solely by the living protoplasm, more or less actively according to the greater or lesser activity of the protoplasm. The substances decomposed are like those oxidized in normal respiration and differ in different species of plants. The products differ according to the plant, the conditions under which it acts, and the substances acted upon.

Alcohol may be produced in considerable amount. This suggests that in both fermentation and intramolecular respiration (if one may separate the two processes, for the former certainly includes the latter as well as nutrition) much of the chemical work may be done by enzymes produced by the respiring organism. Organic compounds and small quantities of many others may also be formed. In germinating peas, the alcohol produced may equal as much as 5% the weight of the moist seeds, enough to give some support to the idea expressed above, that the accumulation of the poisonous products of intramolecular respiration, as in fermentation, may cause the cessation of respiration and the death of the organism.

Between those plants for which aërobic respiration is indispensable to normally active life, and for which anaërobic respiration is only a means of maintaining life over unfavorable periods, and those for which anaërobic respiration is similarly and equally indispensable, there are all connecting stages. These are found among the lower plants, especially the fungi; but, as before stated, in all large multicellular organisms, especially among animals, there are probably cells, lying deep in the tissues, which are forced, by the positions they occupy, to supply themselves with needed kinetic energy by the same means as the anaërobic organisms, *i.e.*, by decomposing the complex compounds which they contain. There are then cells, as well as organisms, which are obligate aërobic, facultative aërobic, or obligate anaërobic. Obligate anaërobic cells and organisms live where the access of free oxygen is impossible or difficult and inadequate; for example, deep in living tissues,

either as component parts of these tissues or as parasites or saprophytes therein ; in the deeper layers of compact soils, in the mud of swamps and marshes, and in the ooze below bodies of comparatively still water, fresh and salt.

As in aërobic, so also in anaërobic respiration, other processes take place simultaneously with it. These, if not directly caused by respiration, are at all events maintained by the energy liberated in respiration and are so closely connected with it that to distinguish between the chemical products of respiration and those of the processes accompanying it, is a matter extremely difficult and still only imperfectly accomplished. Fermentation, decay, and disease at least accompany, if they are not actually a part of, the respiratory processes of certain low plants. Respiration, anaërobic as well as aërobic, is a function of the living protoplasm, which acts upon substances enclosed within its own body, producing simpler substances of which some remain in the respiring cell while others diffuse out of it. Some of the latter are chemically inactive, like carbon-dioxide and alcohol; others may act on substances outside the cell. In higher animals and plants the enzymes (*e.g.*, pepsin, diastase, etc.) are produced in connection with the process of nutrition, converting the substances upon which they act into available food compounds; but it is also certain that, among the enzymes produced, there are some which bring about such changes in the surrounding substances that these become available as sources of kinetic energy.

The diastase formed in the germinating seed, dissolving the starch deposited in the seed as a reserve food and converting it into sugar, makes the reserve food available for at least three purposes: *first*, for the construction of nitrogenous compounds (amides and proteids); *second*, for the formation of cell-wall (cellulose); *third*, for the liberation of energy by respiration. The production and action of this enzyme furnishes material for respiration, nutrition, and growth. The enzymes formed by lower plants are also useful in more than one way, not the least important use being the conversion of irrespirable into respirable substances.

LELAND STANFORD JR. UNIVERSITY.

ON THE SWARMING AND VARIATION IN A MYRIAPOD (FONTARIA VIRGINIENSIS).

ABRAM VARDIMAN MAUCK.[1]

During August, 1898, a swarm of myriapods (*Fontaria virginiensis*) made its appearance in the fields and woods south of the Indiana University Biological Station at Vawter Park. They became conspicuous objects in a roadway which they were crossing, every square foot of which held one or more individuals. Their migration was noticed during the early hours of several days, the swarm going in a northerly direction towards the lake, a little over 100 feet away. No further attempt was made to trace the migration. A few days after the appearance of the swarm all traces of it had vanished. Thirteen hundred and nine individuals were preserved for purposes of statistical study.

Other swarms of myriapods have been reported, and are comparable with the swarms of the Palolo worm during its breeding season. Bollman, *Bull. U. S. Nat. Mus.*, No. 46, p. 75, 1893, records the migration and swarming of the same species noted by the author. He says: "At Donaldson, Arkansas, the adults were found crawling on the ground in company with a large number of their young, probably one adult to 500 or 800 young, then (July 11, 1887) about half grown."

Verhoeff (*Zool. Anzeiger*, Bd. XXIII, p. 465) gives a detailed account of the migration of *Brachyiulus unilineatus* in such numbers in the Hungarian district of Alföld that the railroad track became so slippery, owing to the countless numbers crushed by the wheels, that a train was not able to proceed, though the rails were sanded.

The specimens seen at Vawter Park were all adults and all about the same size. Of twenty females examined, thirteen contained eggs, about 432 in number, the eggs measuring 0.5

[1] *Contribution from the Zoölogical Laboratory of Indiana University*, No. 42.

mm. in diameter. These facts would indicate that August was the breeding time of *Fontaria virginiensis*, some of the females having deposited their eggs, while others still retained theirs.

Of the total number collected, 622, or 47.5171%, are males, and 687, or 52.4828%, are females. Over 100 each of the males and females were studied with the view of determining the occurrence of variations; first, in regard to the number of the segments of the body; second, in regard to the number and bilateral symmetry of the legs; third, in regard to the number of segments in the antennæ.

First, the number of segments was found to be twenty, with no variation whatever from this number; second, the pairs of legs were thirty in the male and thirty-one in the female, with no variations; as far as the number of legs was concerned there was perfect bilateral symmetry; third, the antennæ contain seven segments, and no variation from this number was found.

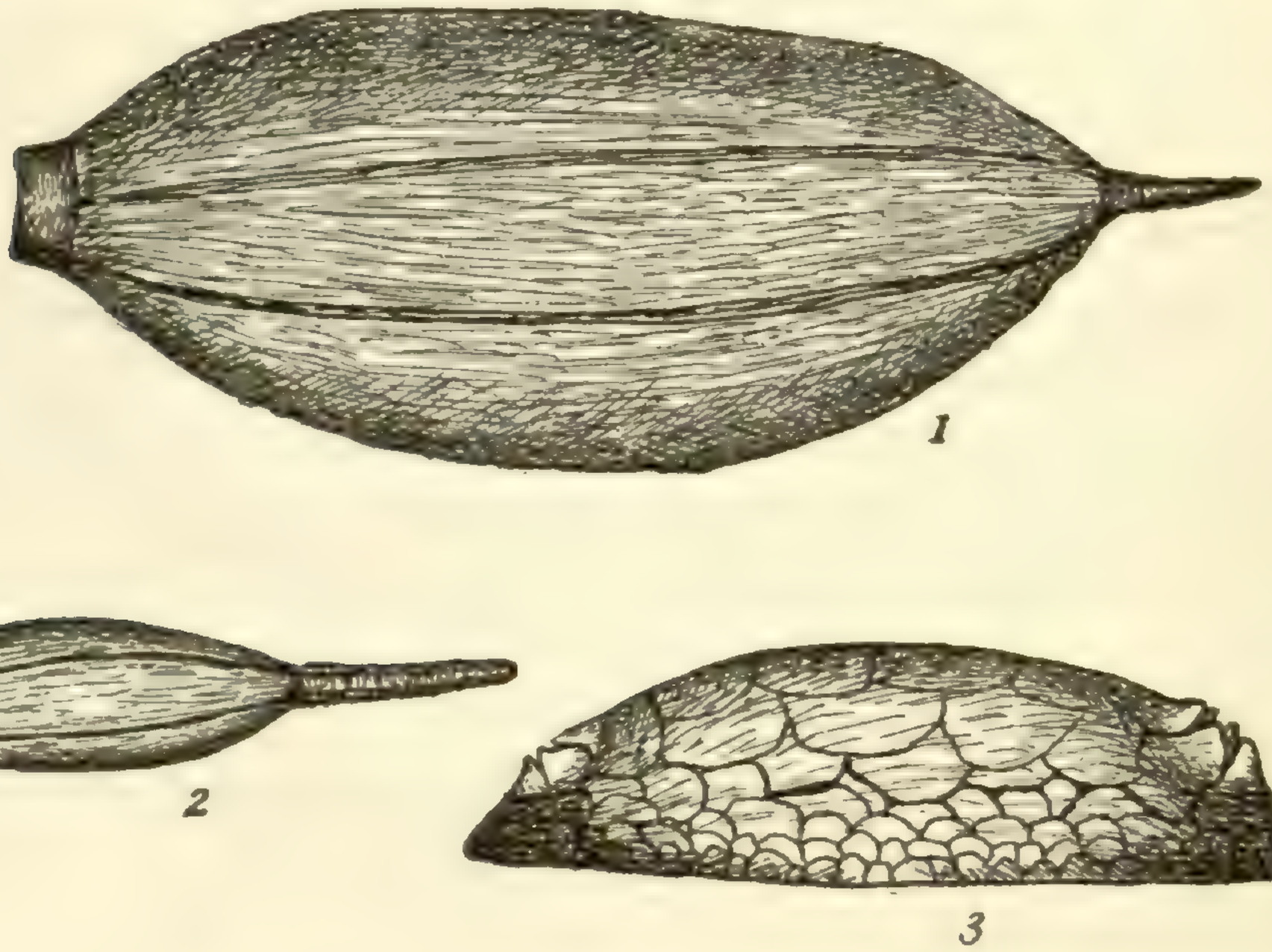
SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XV. The Holothurioidea.

HUBERT LYMAN CLARK.

The holothurians form a sharply defined group of marine invertebrates, especially abundant in the tropics but well represented in both temperate and polar seas. About six hundred species are known, varying in size from ten millimeters to almost a meter in length, and some of the largest species are thirty or forty centimeters in circumference. The colors vary greatly but generally are not brilliant, some shade of brown or gray being the most frequent. Red, however, of various shades is not rare, and green and yellow are also not infrequent. Wholly black or white forms are not uncommon. The shape is often worm-like but is more commonly broader and thicker, often resembling a cucumber, so that the name "sea cucumbers" is frequently given to the group. They are found at all depths, from high-water mark to the bottom of abysses 2900 fathoms from the surface. They are generally sluggish in their movements, and very few forms have any means of rapid locomotion. They feed almost wholly on the organic matter found in the mud or sand where they live, though a few species found among rocks seem to feed upon organic matter growing on the rocks or brought to them in the water. Some species, especially the large ones, live on the bottom where it is muddy or sandy, creeping about very slowly and apparently molested by few enemies. Others, especially the footless forms, live buried in the mud or sand, where they burrow by means of their tentacles and muscular movements of the body wall. Still others occur under or among rocks, often snugly stowed away in some hole or crevice, where they seem to be permanently settled and whence they can only be dislodged by breaking the rock.

Holothurians are easily distinguished from any other invertebrates by the anterior and usually terminal mouth, with a circumoral ring of tentacles, and their curious combination of radial and bilateral symmetry. Although the bilateral symmetry seems usually to predominate, there are always five prominent longitudinal muscles accompanied by nerve strands and vessels of one or more sorts. The body wall is soft or



FIGS. 1–4.

1. *Trochostoma boreale* (Sars). Nat. size.
2. *Caudina arenata* (Gould). Nat. size.
3. *Psolus chitonoides* Clark. Nat. size.
4. *Psolus phantapus* (Struss.). ½ nat. size.

leathery, and generally contains calcareous particles in greater or less abundance. These particles are usually microscopic but are occasionally in the form of large plates several millimeters across. Their size, shape, and arrangement differ to an extraordinary degree in the various genera and species, and they form one of the most satisfactory means of identification. In their simplest condition these calcareous deposits take the form of very minute, more or less irregular grains known as

miliary granules, or somewhat larger straight or curved *rods*, which are often widened and perforated at the end. These rods are almost invariably present in the pedicels, papillæ, and tentacles, and are then known as *supporting rods*. In other parts of the body wall they often are more or less irregularly and profusely branched and then form *rosettes* (Fig. 26). Sometimes the deposits are flat, thin, and wide, and are called *plates*, which may be perforated with smooth-edged holes (Fig. 19), or the holes may have teeth on the edges (Fig. 13). If a perforated plate has a projection rising perpendicularly from the middle, made up of several rods more or less joined together, it is called a *table* (Figs. 15–17, 23–25); the perforated plate being called the *disk* and the projection the *spire*. Sometimes tables occur with the disk reduced or wholly wanting, and sometimes the spire is greatly reduced. Very often the perforated plates are oval or elliptical in shape, with the perforations regularly arranged in pairs, and they are then called *buttons* (Fig. 27); these may be smooth, knobbed, or spiny. Quite often the calcareous particles assume the shape of some familiar object, from which they receive names; as *anchors* (Fig. 12), *wheels* (Fig. 14), *cups* (Figs. 20–22), etc. In a few species these calcareous deposits seem to be wholly wanting; in some they are confined to special regions of the body; in many, two or more different kinds are found, usually in separate layers of the body wall; and in a few they are so abundant, or so large and close together, as to make the body wall stiff, and sometimes firm, or even rigid. Beside these colorless calcareous deposits, we find in a few genera (Trochostoma and its allies) reddish-brown or claret-colored concretions (Fig. 18), which are often so abundant as to give their color to the whole animal, or at least to large spots and patches. In such species the calcareous deposits themselves are often deeply tinged with the same coloring matter as the concretions, but usually they are free from it. In a few genera prominent tooth-like bits of lime, usually five in number, are grouped around the anus. These are called *anal teeth*.

Around the œsophagus is a ring made up of plates of lime, known as the *calcareous ring*. There are usually ten of these

plates; five serve as points of attachment for the radial muscles and are called *radial pieces*, while the five which alternate with them are called *interradial*. The size and shape of these pieces differ greatly, the most important difference being whether they have *posterior prolongations* (Fig. 7) or not (Fig. 8). The tentacles around the mouth vary greatly in number and appearance. There are usually ten or twenty, but species are known which have normally eight, eleven, twelve, fifteen, eighteen, and twenty-five, and in individual cases the number runs up to thirty. In some species the number is very constant, and individual diversity is quite rare; while in other species the amount of diversity is extraordinary, ranging in some species of *Holothuria* which have normally twenty tentacles, from twelve to twenty-nine. In appearance the tentacles may be simple, finger-like, and unbranched, but this condition is very uncommon. Usually each tentacle has several to many branches; when these all arise in a tuft from near or at the tip and are more or less subdivided, the tentacle is called *peltate* (Fig. 10); when the branches occur regularly along the sides in two opposite series and without subdivisions, the tentacle is *pinnate*, or, if the branches are very few and all arise from the tip, *digitate* (Fig. 11); when the branches are subdivided and irregularly arranged the tentacle is said to be *dendroid* (Fig. 9). In some species these tentacles are used for locomotion, but they are more commonly used as feelers and to carry food to the mouth. Locomotion is generally accomplished by means of *ambulacral-* or *tube-feet*, as in the other echinoderms. These feet, when present, may be arranged in regular rows along the five radii (*ambulacra*), or scattered more or less irregularly over the whole body surface. Frequently those on the upper side of the animal are very different in size, appearance, and structure from those on the under or ventral side, and no longer serve for locomotion, the terminal sucking disk being generally absent. They are then called *papillæ*, the true-feet being *pedicels*.. Rarely, all the tube-feet are papillæ and no pedicels normally occur. The papillæ are often situated on warts or tubercles, and these are sometimes of considerable size. The pedicels are frequently

confined to the ventral surface and are there often arranged in three broad longitudinal series. Many holothurians have a pair of long, much-branched outgrowths of the wall of the cloaca lying in the body cavity, one on each side of the intestine. These serve for excretion, and perhaps for respiration, and are called the *respiratory trees*. Their presence or absence is of importance in classification. The stomach and anterior

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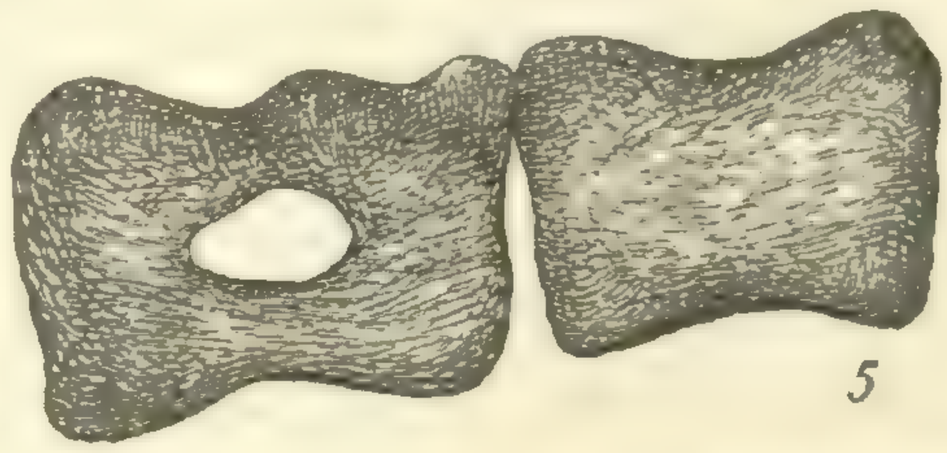

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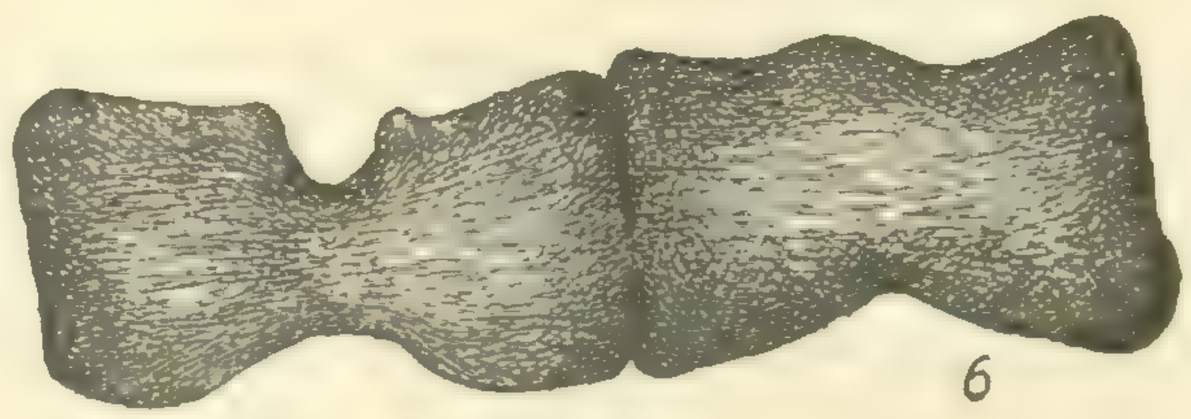

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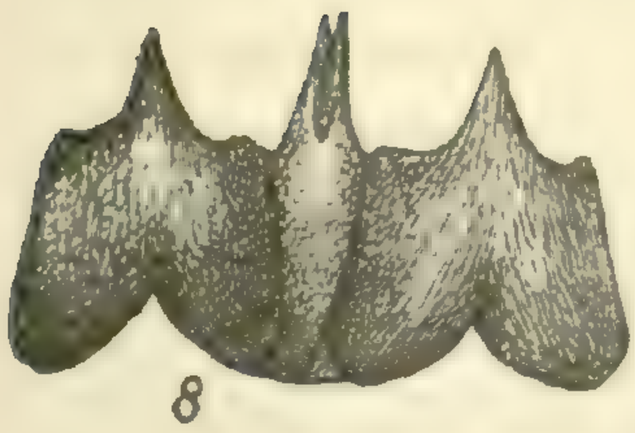

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FIGS. 5–11.

5. A radial and interradial piece of the calcareous ring of *Synapta inhærens* (O. F. Müll.). × 45.
6. The same of *Synapta roseola* (Verr.). × 45.
7. A radial and two interradial pieces of a "calcareous ring with posterior prolongations." *Thyone briareus* (Less.). × 3.
8. The same of a "calcareous ring without posterior prolongations." *Thyone suspecta* Ludw. × 3.
9. A dendroid tentacle. *Cucumaria punctata* Ludw. × 3.
10. A peltate tentacle. *Holothuria surinamensis* Ludw. × 3.
11. A digitate tentacle. *Trochostoma boreale* (Sars). × 5.

portion of the intestine are held in position by a thin membrane attached to the body wall in the mid-dorsal line, and called the dorsal *mesentery*. In this lies the genital duct, and the genital glands lie in groups or tufts either on one or both sides of it. In some holothurians the long radial muscles are divided anteriorly, one-half continuing attached to the body wall and serving merely as a longitudinal muscle, while the other is free

from the body wall and is attached at the end to the radial piece of the calcareous ring. By their contraction these five muscles serve to draw the tentacles and whole anterior end of the animal back into the body cavity for protection, and they are therefore called the *retractor* muscles.

Owing to the fact that the early describers of holothurians paid little attention to internal characters, and none whatever to the microscopic deposits in the skin, it is difficult, if not impossible, to determine from one of their descriptions what species is meant. Even within the past forty or fifty years so much importance has been attached to those characters in which there is the greatest individual diversity (size, shape, color, number of tentacles, arrangement of pedicels, etc.) that the same species has been described under a number of different names. Many of our common species have two or three synonyms, some have four or five, and one has no less than eleven! As very few types of the species described by the earlier writers are now in existence, the untangling of this snarl of synonyms is no easy task. No less than eighty-eight different specific names have been given to holothurians from the shallow waters of North America; but these seem to be reducible to at most forty-seven valid species, and very probably the correct number now known is under forty-five. Since many of the names in most common use in this country are incorrect, they will be looked for in vain in this key. In order that such forms may be properly placed, the following list of synonyms is given. It is not intended as a complete synonymy of the species given in the key, but is simply an alphabetical list of names incorrectly applied, or no longer in use by the best authorities.

There are a number of such generic names, as follows:

Actinopyga Brown	= *Mülleria*	of the key.
Anaperus Troschel	= *Thyone*	" " "
Botryodactyla Ayres	= *Cucumaria*	" " "
Cladodactyla Brandt	= *Cucumaria*	" " "
Cuvieria Peron (?)	= *Psolus*	" " "
Embolus Selenka	= *Trochostoma*	" " "
Echinosoma Semper	= *Eupyrgus*	" " "
Leptosynapta Verrill	= *Synapta*	" " "

Liosoma Brandt	= *Chiridota*	of the key
Liosoma Stimpson	= *Trochostoma*	" " "
Lophothuria Verrill	= *Psolus*	" " "
Ocnus Forbes	= *Cucumaria*	" " "
Pentacta Jäger	= *Cucumaria*	" " "
Pentamera Ayres	= *Thyone*	" " "
Sclerodactyla Ayres	= *Thyone*	" " "
Semperia Lampert	= *Cucumaria*	" " "
Stereoderma Ayres	= *Thyone*	" " "
Synaptula Oerstedt	= *Synapta*	" " "
Thyonella Verrill	= *Thyone*	" " "
Trochinus Ayres	= *Chiridota*	" " "

Below are the specific names the use of which is no longer correct:

affinis (*Botryodactyla*) Ayres	= *Cucumaria frondosa*	of the key.
albicans (*Synapta*) Selenka	= *Synapta inhærens*	" " "
albida (*Cladodactyla*) Brandt	= *Cucumaria populifer*	" " "
albida (*Cucumaria*) Ludwig	= *Cucumaria populifer*	" " "
ayresii (*Ocnus*) Stimpson	= *Cucumaria minuta*	" " "
ayresii (*Synapta*) Selenka	= *Synapta inhærens*	" " "
botellus (*Holothuria*) Selenka	= *Holothuria impatiens*	" " "
brevis (*Chiridota*) Huxley	= *Myriotrochus rinkii*	" " "
carolina (*Thyone*) Selenka	= *Thyone briareus*	" " "
cigaro (*Thyone*) Troschel	= *Thyone briareus*	" " "
hispidum (*Echinosoma*) Semper	= *Eupyrgus scaber*	" " "
lævigatus (*Psolus*) Ayres	= *Psolus phantapus*	" " "
musculosum (*Thyonidium*) Ayres	= *Thyone elongata*	" " "
oolitica (*Molpadia*) Selenka	= partim *Trochostoma boreale* of the key. partim *Trochostoma ooliticum* of the key.	
pallidus (*Trochinus*) Ayres	= *Chiridota lævis*	of the key.
pauper (*Embolus*) Selenka	= *Trochostoma ooliticum*	" " "
pellucida (*Synapta*) {Stimpson & Kurtz}	= *Synapta inhærens*	" " "
pentacta {*Cladodactyla* Brandt; *Holothuria* O. F. Müller}	= *Cucumaria frondosa*	" " "
piperata (*Pentacta*) Stimpson	= *Cucumaria nigricans*	" " "
pourtalesii (*Synapta*) Selenka	= *Synapta vivipara*	" " "
punctata (*Orcula*) Agassiz	= *Orcula barthii*	" " "
fallax (*Cucumaria*) Ludwig	= *Cucumaria miniata*	" " "
floridana (*Holothuria*) Pourtales	= *Holothuria atra*	" " "

fusiformis (*Cucumaria*) Desor	= *Thyone unisemita*	of the key
***fusus* (*Thyone*) Verrill**	= ***Thyone scabra***	" " "
girardii (*Synapta*) Pourtales	= *Synapta inhærens*	" " "
glabrum (*Thyonidium*) Ayres	= *Thyone briareus*	" " "
gracilis (*Synapta*) Selenka	= *Synapta inhærens*	" " "
grandis (*Botryodactyla*) Ayres	= *Cucumaria frondosa*	" " "
***granulatus* (*Psolus*) Ayres**	= ***Psolus regalis***	" " "
sitchænse (*Liosoma*) Brandt	= *Chiridota discolor*	" " "
***sitchænsis* (*Cuvieria*) Brandt**	= ***Psolus fabricii***	" " "
***tenella* (*Thyone*) Selenka**	= ***Thyone briareus***	" " "
***tenuis* (*Synapta*) Ayres**	= ***Synapta inhærens***	" " "
tigillum (*Chiridota*) Selenka	= *Chiridota lævis*	" " "
turgidum (*Molpadia*) Verrill	= *Trochostoma boreale*	" " "
typicum (*Chiridota*) Selenka	= *Chiridota lævis*	" " "
viridis (*Synapta*) Pourtales	= *Synapta vivipara*	" " "

The following species are so very poorly described and so little known it is impossible even to assign them as synonyms:

Holothuria tentaculata Forster, *Synapta bachei* Ayres.

The artificial key given on pp. 487, 488 is intended to include and make possible the identification of every known species of holothurian which occurs on the coasts of America, north of Mexico, in less than 100 fathoms of water. There are a few species which probably occur within these limits (as they have been taken just outside), but they are not included in this key. The holothurians of Florida and the Gulf coast and those of the Pacific coast are almost unknown, and the geographical range of even our most common species is very imperfectly known. It has therefore been thought best to give as exactly as possible the localities where the various species have been taken. There are five species included in the key which are new to science and the descriptions of which have not yet been published; but descriptions and figures are now in press of two of these forms, which were collected in Puget Sound in 1896 and 1897 by the zoölogists of Columbia University. These are *Psolus chitonoides* Clark and *Cucumaria lubrica* Clark. The third species is *Cucumaria curata* Cowles, also from the Pacific coast. Mr. H. P. Cowles is now engaged in a study of the life history of this species, and in advance of his own publication he has very kindly given me the name he has

Artificial Key to the Genera of North-American Holothurians.

- **Without pedicels or papillæ**
  - **Without respiratory trees (Synaptidæ)**
    - Calcareous deposits in skin, consisting of anchors and plates (Figs. 12 and 13) . . . . . **Synapta**
    - Calcareous deposits in skin, wheels with 6 spokes (Fig. 14), collected in little heaps . . . . . **Chiridota**
    - Calcareous deposits in skin, scattered wheels with about 19 spokes . . . . . **Myriotrochus**
  - **With respiratory trees (Molpadiidæ)**
    - Tentacles simple, unbranched; calcareous ring without posterior prolongations . . . . . **Eupyrgus**
    - Tentacles digitate (Fig. 11); calcareous ring with posterior prolongations.
      - Caudal portion of body short, abrupt (Fig. 1); calcareous deposits, when present, more or less imperfect tables, reddish-brown ellipses, or both . . . **Trochostoma**
      - Caudal portion of body long, tapering (Fig. 2); calcareous deposits, perforated disks or tables with a narrow spire . . **Caudina**

ARTIFICIAL KEY TO THE GENERA OF NORTH-AMERICAN HOLOTHURIANS (*Continued*).

- With pedicels or papillæ, or both
  - Tentacles dendroid (Fig. 9). Retractor muscles present. (Dendrochirotæ)
    - 10 tentacles
      - Ventral surface flattened to form a creeping sole, on which the pedicels are arranged in 3 longitudinal series.
        - Pedicels wanting on the dorsal surface . . . . . Psolus
        - Pedicels numerous all over the dorsal surface . . . . Thyonepsolus
      - Ventral surface not notably flattened.
        - Pedicels numerous all over the body, not at all arranged in rows on the ambulacra . . . . Thyone
        - Pedicels in rows on the ambulacra; scattered or wanting on the interambulacra . . . . . Cucumaria
    - 15 tentacles . . . . . Orcula
    - 20 tentacles . . . . . Thyonidium
  - Tentacles peltate (Fig. 10). Retractor muscles wanting. (Aspidochirotæ)
    - Anal teeth present; genital glands in a single tuft beside the mesentery . . . Mülleria
    - Anal teeth wanting
      - Genital glands in a tuft on each side of the mesentery . . . Stichopus
      - Genital glands in a single tuft on the left side of the mesentery . . . . . Holothuria

adopted and the diagnostic characters of this interesting little holothurian. The remaining two species are very curious and noteworthy ones from the coast of California, collected during the summer of 1900 by Mr. Benjamin Thomas. They are *Thyone rubra* Clark and *Thyonepsolus nutrians* Clark. Descriptions of these two species are now in press. Each of these five species bears at present only a *nomen nudum*, but it has seemed best to include them, nevertheless, in order to make the key as complete as possible.

Key to the Species under each Genus.

Synapta.

Radial pieces of calcareous ring perforated for passage of the nerve. (Fig. 5)

- Viviparous; 100 mm. long; reddish-brown or greenish, flecked with white; lives in seaweed . . . . . *S. vivipara* (Oerst.)

  Biscayne Bay, Florida; Bermuda, Jamaica; Brazil.

- Not viviparous; larger, 250 mm.; white, yellowish, or pale pinkish; lives buried in sand or mud . . . . . *S. inhærens* (O. F. Müll.)

  Widely distributed in Northern Hemisphere; Maine to South Carolina in Western Atlantic; Puget Sound, southward on Pacific coast. Also Mediterranean, Eastern Atlantic, North Sea, and Arctic Ocean.

Radial pieces of calcareous ring, not perforated but merely notched (Fig. 6); 100 mm.; rosy red . . . . . *S. roseola* (Verr.)

Occurs under loose rocks or buried in the sand. Southern side of Cape Cod, Buzzards Bay, Long Island Sound, and Bermuda.

Chiridota.

Wheel papillæ very numerous, scattered over all the interambulacra; besides wheels there are many small slightly curved rods *C. rotifera* (Pourt.)

Viviparous; 100 mm. long; deep flesh color, wheel papillæ white; under stones and loose rocks, and in sand; Key West, Biscayne Bay, Bermuda, Jamaica, and Brazil.

Wheel papillæ in rows of 20-30 in each dorsal interambulacrum and 3-12 in each ventral one; North Atlantic coast . . . *C. laevis* (Fabr.)

Wheel papillæ in only three interambulacra; Alaskan species *C. discolor* Esch.

These last two species are practically indistinguishable, and further study will probably show them to be identical. Occur under rocks, or in sand or mud in comparatively shallow water; may reach a considerable size; color very variable, from gray to pink.

Myriotrochus.

Small, 50–60 mm.; blackish or dusky; tentacles light . . . *M. rinkii* Steens.

Circumpolar; northeastern America as far south as Labrador. Occurs in water not over 300 fathoms deep.

Eupyrgus.

Very small, 10 mm.; grayish . . . . . *E. Scaber* Ltk.

Labrador, Greenland, Spitzbergen, Kara Sea. At depths of 4–240 fathoms, generally on muddy bottom.

Trochostoma (Fig. 1).

Deposits wanting; integument smooth and leathery; body spindle-shaped, 100 mm.; yellowish or reddish-white with reddish-brown patches . . . . . *T. arenicola* Stimp.

Coast of southern California.

Deposits, reddish-brown, concentric ellipses (Fig. 18) usually in such quantities as to give part or all of the animal a dark red color; skin grayish.

With colorless calcareous tables, more or less imperfect (Fig. 17), in addition to the ellipses *T. boreale* (Sars)

An Arctic species, reported from the coast of Florida, Lesser Antilles, and Maine. Verrill's *Molpadia turgidum*, probably this species, was taken at various points on the New England coast up to the Gulf of St. Lawrence, in 40–100 fathoms.

Without tables . . . . . *T. ooliticum* (Pourt.)

Boston, Block Island, Boon Island. Very possibly identical with the preceding.

Caudina (Fig. 2).

Medium size, 50–100 mm.; about one-third consisting of the long, narrow tail . . . . . *C. arenata* (Gould)

New England coast, Revere Beach, Grand Manan (?), Chelsea, and Vineyard Sound. Occurs buried in the sand in shallow water.

Psolus (Figs. 3 and 4).

Body subcylindrical; anal region elongatedly conical caudiform; pedicels in three complete rows on ventral surface (Fig. 4).

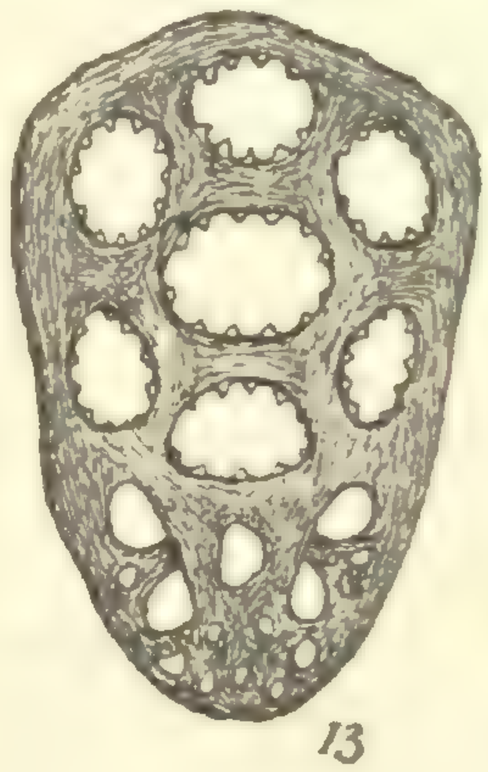
Dorsal perisome without large plates; with numerous minute perforated plates and round granules . . . . . *P. regalis* Verrill

Banks of Newfoundland, in thirty fathoms.

Dorsal perisome with large granulated scales, imbricated . . . . . *P. phantapus* (Struss.)

North Atlantic and Arctic oceans; on American coast as far south as Massachusetts; occurs from low water to 130 fathoms.

12



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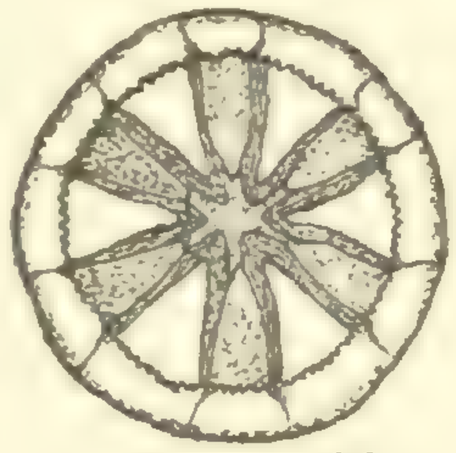

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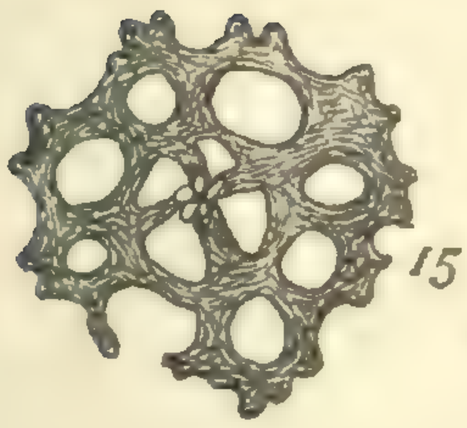

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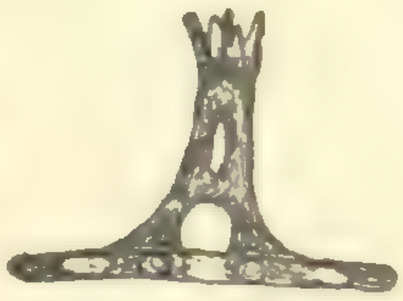

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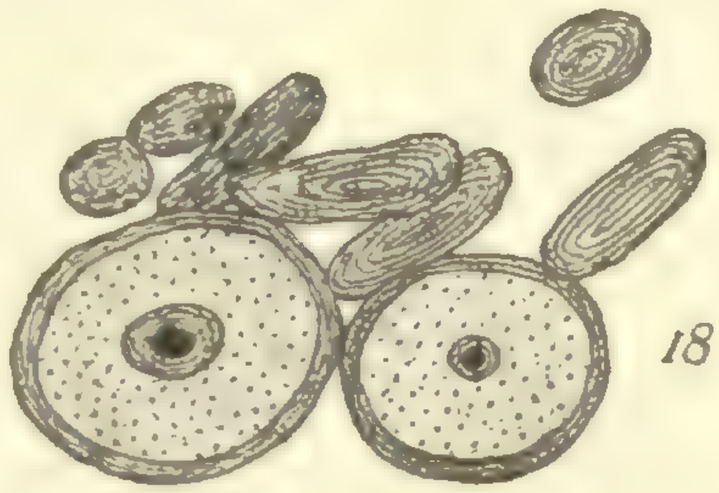


18

FIGS. 12–18.

12. Anchor of *Synapta inhærens* (O. F. Müll.). × 225.
13. Plate of the same species. × 225.
14. Wheel of *Chiridota rotifera* (Pourt.). × 225.
15. Table of *Caudina arenata* (Gould). Seen from above. × 105.
16. The same; seen from the side. × 105.
17. Table of *Trochostoma boreale* (Sars). × 105.
18. Reddish-brown deposits of *Trochostoma boreale* (Sars). × 105.

Body depressed oval, chiton-shaped (Fig. 3); anal region not prolonged; **pedicels forming complete rows** only on sides of ventral surface; dorsal surface covered with large imbricated scales; color generally some shade of orange or red.

Dorsal scales with fine granulations; sole with scattered, irregular, reticulate plates; 130 mm. *P. squamatus* (D. & K.)

North Atlantic; common on New England coast in shallow water. Pacific Grove, Cal. (?)

Dorsal scales with coarse granules; sole with reticulate cups or spheres . . *P. fabricii* (D. & K.)

Smaller than preceding, but possibly identical with it; eastern North America from Massachusetts to Greenland; also on Alaskan coast.

Dorsal scales, without evident granules; sole with crowded knobbed, perforated plates; 65 mm. . . . . . *P. chitonoides* Clark

Puget Sound.

Thyonepsolus.

Size small, 20 mm. long by 8 wide; red; deposits, reticulated cups and very irregular perforated plates; carries the young on the back. On rocks along shore at Pacific Grove, Cal. . . . *T. nutrians* Clark

Cucumaria.

Size large, up to 600 mm.; deposits, when present, irregular smooth perforated plates — *C. frondosa* (Gun.)

Brown; practically circumpolar; on Atlantic coast of America south to Florida; on Pacific coast, to Lower California (?).

Pedicels scattered more or less on the interambulacra. See also *C. miniata* in the next section.

Size small, 40–50 mm.; deposits, irregular knobbed buttons, sometimes with four symmetrically placed holes, but more often with several scattered ones . . . . . — *C. lubrica* Clark

Pale brownish gray; Puget Sound.

Size very small, 15–20 mm.; deposits rather thick, smooth buttons, with from 1–9 holes and, in the ventral wall, a few much larger plates with much larger holes . . — *C. curata* Cowles

Black; "eggs laid and cared for by mother; brooded under ventral surface." "Pacific Grove, Cal., and possibly in region near San Francisco."

Pedicels present only on the ambulacra, and there generally in one or two rows.

Deposits minute, reticulate cups and roundish or oval buttons with four holes — *C. quinquesemita* Sel.

Mendocino, Cal.. (Other specimens were labeled "Charleston," but this is probably a mistake.)

Deposits scattered irregular perforated plates, with one end drawn out as a spire or dentate process . . . . . — *C. albida* Sel.

Yellowish (white in alcohol) with brown spots; 80 mm. Mendocino and Pacific Grove, Cal.

Deposits polygonal plates with 25–40 holes and a central sharp spine . . . . . — *C. populifer* (Stimp.)

130 mm.; Sitka and Puget Sound.

Deposits an inner layer of narrow oblong plates with two or three rows of holes and an outer layer of tables . . . . . — *C. calcigera* (Stimp.)

120 mm.; Massachusetts, Labrador, Greenland, and Arctic Ocean. Pacific Grove, Cal.

Deposits irregular spinous rods or spicules — *C. nigricans* (Brandt)

Dusky yellowish-brown; 60 mm.; Sitka and Puget Sound.

Deposits a very crowded inner layer of hollow fenestrated ellipses and an outer layer of small reticulate cups or spheres . . . — *C. chronhjelmi* Théel

White; 70 mm.; Vancouver Island and Puget Sound. Pacific Grove, Cal.

Deposits roundish perforated plates . — *C. minuta* (Fabr.)

Clear brownish; 10 mm.; Grand Manan to Arctic Ocean.

Deposits "in numerous inseparable perforated layers, their true shape not fully clear"

C. pulcherrima (Ayres)

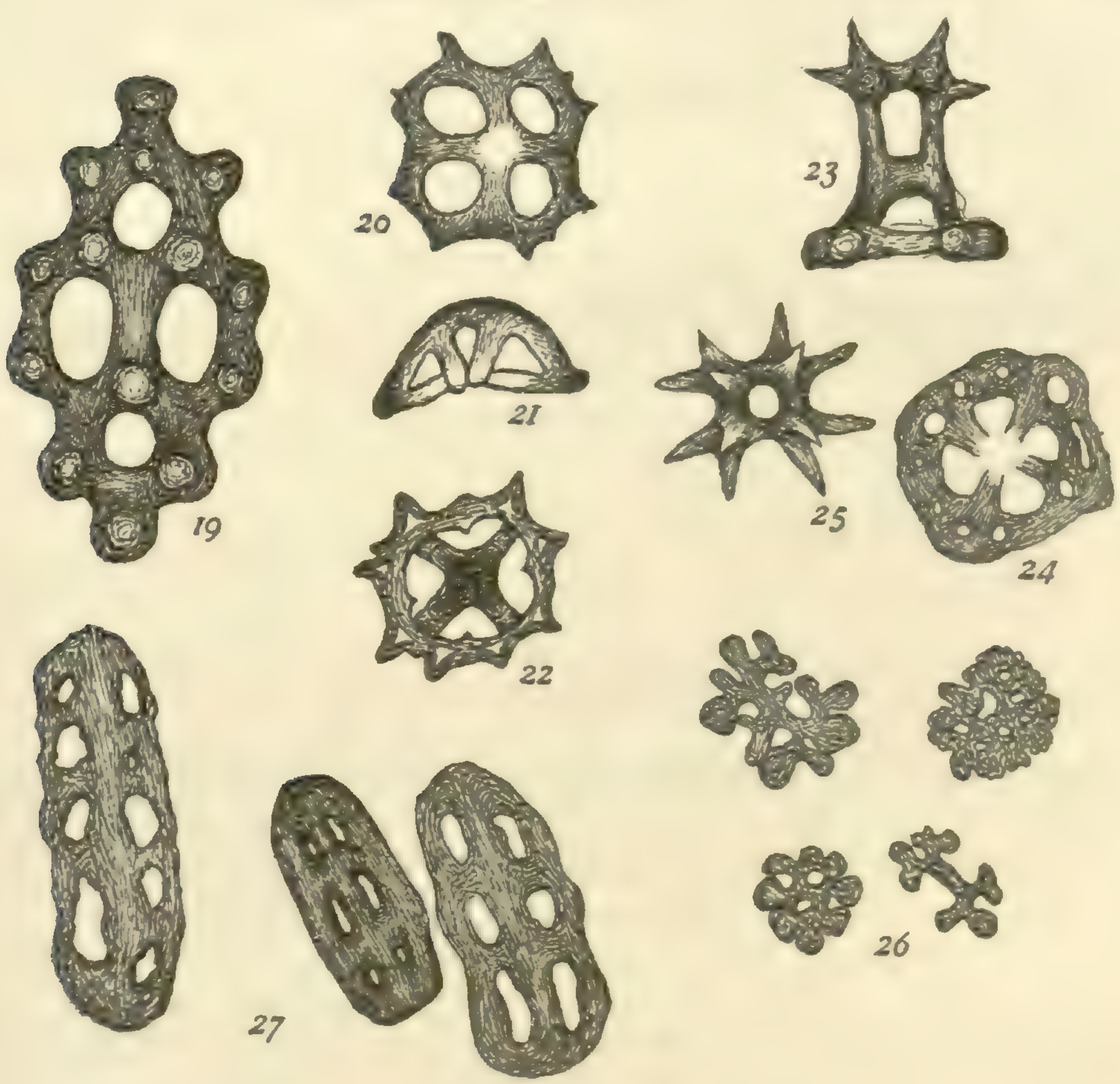
Eastern United States from Vineyard Sound south to South Carolina. This species needs a reëxamination.

Pedicels present only on the ambulacra, and there generally in one or two rows.

Deposits crowded, thick, knobbed buttons or plates with few or many perforations, and one end drawn out into a thorny spine or process

C. miniata (Brandt)

Pinkish-white; 40 mm.; Alaska and Pacific Grove, Cal. (?). This species is not well defined. Ludwig thinks it identical with *C. albida* Sel., but there are two species at Pacific Grove, Cal., one of which is apparently *albida*, and the other is clearly distinct from it, but answers to the description of *miniata*. There are pedicels, however, on all of the interambulacra in the specimens from Pacific Grove.



FIGS. 19–27.

19. Knobbed plate of *Thyone suspecta* Ludw. × 450.
20. Cup of same species; seen from without. × 450.
21. The same; seen from the side. × 450.
22. The same; seen from within. × 450.
23. Table of *Holothuria atra* Jaeger; seen from the side. × 450.
24. The disk of the same. × 450.
25. The top of the same. × 450.
26. Branched rods and rosettes of same species. × 450.
27. Buttons of *Holothuria captiva* Ludw. × 450.

Thyone.

Deposits in body wall wanting . . . . . *T. briareus* (Less.)

Dark brown, almost black; 150 mm.; in mud, Cape Cod to Texas.

Deposits in the form of tables . . . . . *T. scabra* Verrill

Brownish; 50 mm.; coast of New England to Chesapeake Bay.

Deposits small reticulate cups and uneven oval buttons with four holes *T. gemmata* (Pourt.)

Body spindle-shaped, dusky brown; North Carolina to Brazil (?).

Deposits unperforated rods . . . . . *T. elongata* (Ayres)

Banks of Newfoundland, in thirty fathoms; Massachusetts Bay (?).

Deposits crowded oval buttons with four holes . . . . *T. unisemita* (Stimp.)

Brownish-gray; 60–75 mm.; coast of New England from Nantucket northward.

Deposits buttons with four holes, and very numerous large complex tables . . . . . *T. rubra* Clark

Red above, whitish below; 20 mm.; viviparous; Pacific Grove, Cal.

Orcula.

Size medium, 65 mm.; brownish; deposits wanting . . . *O. barthii* Troschel

Labrador, Greenland, and the Arctic Ocean.

Thyonidium.

Size small, 15 mm.; pale yellowish; deposits few . . . *T. productum* (Ayres)

Eastport and Grand Manan.

Mülleria.

Tentacles 20; deposits tables and buttons . . . . . *M. parvula* Sel.

Chestnut-brown; 50 mm.; Florida.

Tentacles 25–30; tables and buttons wanting; deposits small branched rods . . . . . *M. agassizii* Sel.

Light brown mottled with darker; 300 mm.; Florida and West Indies.

Stichopus.

Tables with round perforated disk; no buttons . . . . . *S. badionotus* Sel.

Olive green or olive brown; 200 mm.; Florida.

Tables without disk; no buttons . . . . . *S. sitchænsis* (Brandt)

90 mm.; Alaska. The status of this species is doubtful.

Tables with well-developed disks; numerous buttons with nine pairs of holes . . . . . *S. californicus* (Stimp.)

Brown; 300 mm.; coast of California, Puget Sound.

Holothuria.

Papillæ on dorsal, pedicels on ventral surface.	Deposits tables and very numerous small irregular perforated plates . . . . . *H. atra* Jäger Dark brown; 300 mm.; widely distributed in the tropics; Florida.
	Deposits tables and two kinds of perforated buttons . . . . . *H. rigida* Sel. Olive brown; 70 mm.; Florida (also Zanzibar and Society Islands).
Papillæ on both dorsal and ventral surfaces; no pedicels; deposits tables and one kind of perforated buttons.	Disk of tables with a smooth margin *H. impatiens* (Forsk.) Dark purplish or grayish, more or less blotched with darker; 150 mm.; very widely distributed in the warmer seas; Florida.
	Disk of tables with twelve prominent horizontal teeth on margin . . . . . *H. princeps* Sel. Dark brown; 120 mm.; Florida.

THE MOST IMPORTANT PAPERS DEALING WITH THE SHALLOW-WATER HOLOTHURIANS OF NORTH AMERICA ARE AS FOLLOWS.

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STIMPSON, W. (*a*) Descriptions of New Species of Holothurians. *Proc. Bost. Soc. Nat. Hist.* Vol. iv. 1854.

(*b*) Synopsis of the Marine Invertebrates of Grand Manan. 1853.

(*c*) On the Crustacea and Echinoderms of the Pacific shores of North America. *Bost. Journ. of Nat. Hist.* Vol. vi. 1857.

THÉEL, H. Report on the Holothurioidea. *Challenger Reports.* Vol. xiv, pt. xxxix. 1886.

VERRILL, A. E. (*a*) Report on the Invertebrate Animals of Vineyard Sound. *Report of the Comm. of Fish and Fisheries.* 1874.

(*b*) Preliminary Check-List of Marine Invertebrates of the Atlantic Coast from Cape Cod to the Gulf of St. Lawrence. 1879.

See also

(*c*) *Proc. Bost. Soc. of Nat. Hist.* Vol. x. 1864.

(*d*) *Trans. Conn. Acad. of Sci.* Vol. i, pt. ii. 1867–71.

(*e*) *Report of Comm. of Fish and Fisheries.* 1881 and 1883.

(*f*) *Proc. U. S. Nat. Museum.* 1879 and 1885.

(*g*) *Amer. Journ. of Sci.* 1879 and 1882.

OLIVET COLLEGE, OLIVET, MICH.,
November, 1900.

EDITORIAL COMMENT.

Death of Dr. Lütken. — Copenhagen advices notice the death of Dr. Christian Frederik Lütken, the honored Emeritus Professor of Zoölogy in the University at Copenhagen and one of the most eminent of modern zoölogists. Dr. Lütken was born in 1828, and was seventy-three years of age at the time of his death. He is the author of many scientific papers, the most important being on fishes, and his best work being on the fishes of the open sea and the changes passed through in their development. The most extensive of these is a series called "Spolia Atlantica," discussing the rich material brought in by Danish seamen. Other notable papers are on the lantern fishes, the flying fishes, the remoras, the sculpins, the fishes of Greenland, and the fresh-water fishes of Brazil.

In all his work Dr. Lütken was extremely conservative, never jumping at a conclusion, and content to leave a question unsettled in default of adequate material to form an opinion. Thus few scientific men have had fewer errors to correct than he.

Dr. Lütken at fifty-five is remembered as a large man with a fine face, hale and hearty, and one of the most genial and helpful of all European ichthyologists.

School Science is the title of a new journal devoted to the interests of science teaching in secondary schools. It is published in Chicago, and edited by C. E. Linebarger, with the assistance of a number of science teachers scattered over the country; and is intended by the editors to be conducted by and for the science teacher.

Within the last few years, largely because of the employment of college-trained teachers in the secondary schools, the quality of the work done in these schools has been vastly improved, especially in the line of science, and for its grade no better work is done in science to-day than that done in a few American high schools. To enlarge the field of the teachers to whom this success is due, and to widen their influence, is the mission of the new journal, which merits the support of all who see the desirability of having science scientifically taught.

Goode Memorial Volume. — No more appropriate memorial can be paid a scientific man than the republication of his papers contributed to scientific societies and journals. The writings of George

Brown Goode relating to museums and to the development of science in America are among the most important issued, and the United States National Museum has done a real service in reprinting a selection of the same. (A Memorial of George Brown Goode, with a Selection of his Papers on Museums and on the History of Science in America, *Ann. Rept. Smithsonian Institute, Rept. U. S. Nat'l Museum*, Pt. II, 515 pp., 110 pls., 1901.)

Editorially the volume shows the faults due to inadequate care that are common to many of the publications of the United States National Museum. A few instances, taken quite at random, may be mentioned: page 4, the invitation to the Memorial meeting is cited as part of the program, the actual program following on page 5; a footnote with reference to the original place of publication should have been given with all of the reprinted papers; even as given, the footnotes are not always accurate; on page 459 the names of many scientific men appear, some as "leading spirits," others as "rising men," but it is not easy to divine why all the leading spirits should be indexed and all the rising men, save Powell, should be omitted from the index; on the same page (459) Ordway, mentioned as leaving the ranks of science for the army, is indexed as John M., a mistake for Albert; the bibliography needs revision; the titles in some cases are not exact; on page 490 the address "The Beginnings of American Science" is recorded as delivered at the eighth anniversary meeting of the Biological Society of Washington, a statement at variance with the footnote on page 409; the Oceanic ichthyology of Goode and Bean was published as Vol. XXII of the *Memoirs of the Museum of Comparative Zoölogy* as well as a special bulletin of the *U. S. National Museum*, but the reference to the *Memoirs* is omitted on page 496; the astronomer Tycho Brahe is indexed under T as Tycho Brake, an editorial oversight recalling Judge Story's great mind and Lyell's correspondent Tromsö.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

General Observations on Anthropometry.[1] — Under the title "Généralités sur l'Anthropométrie," Professor Manouvrier has recently published a paper which ought to be carefully read *in extenso* by every prospective as well as actual student, and by every instructor, in that branch of anthropology. Manouvrier, one of Broca's scholars and for many years a professor and a practical teacher of anthropometry in the Paris School of Anthropology, is, it scarcely needs to be mentioned, eminently qualified to express himself on the subject chosen.

The aims of the paper are, in brief, the imparting of a better understanding of the whole subject of measuring; showing an urgent necessity for all disciples and workers in anthropometry of an ample preliminary biological training, and of practical apprenticeship in the technique of measuring, with a competent teacher; and a warning against any laxity in or needless modifications of the methods of measuring, the use of imperfect instruments, and faults in the conception of, or conclusions from, the work undertaken.

Accurate data are precious aids in the study of man; inaccurate data, gathered by incompetent observers, through the means of imperfect instruments, a lax or faulty technique, serve only to encumber the science with harmful material and retard its progress, and to discredit the whole procedure of measuring. This is not only applicable to the study of man's physical, but also to that of his physiological and psychical characters.

The system of measuring man or any part of the human system appears simple only to those of shallow understanding or superficial instruction. "Anthropometry is a procedure of anatomical research as much as dissection," and correct measuring does not require less instruction in anatomy or less technical experience than correct dissection. But the operations of anthropometry furnish a greater variety of conditions in which a proper judgment has to be exercised,

[1] Manouvrier, L. *Revue de l'École d'Anthropologie de Paris*, vol. xii (December, 1900), pp. 413–439.

more errors necessary to obviate, more diversity of the manner of action, than dissection. "Far from being more elementary, anthropometric researches presume a preceding acquisition of knowledge by dissection."

Anthropometry is "a procedure of anatomical analysis, serving to make more precise the description of the innumerable variations of the human body." A thorough knowledge of all these variations, unattainable by unaided observation, is necessary to anthropology, which, in the definition of the author, is "a synthetic knowledge of the human beings, the species, groups, categories, individuals." In order that anthropometry should prove of full value and its data lend themselves with the greatest attainable facility to biological interpretations, it requires in practice the greatest possible precision and the maximum of rationality from the anatomical standpoint.

In all his work the one who measures should have a well-defined aim, but be free of preconceived notions; he should have a precise definition as to what is to be measured and registered, at least an approximative estimation of the aptness of the instruments used to answer the requirements, and a practical knowledge of the technique of his measuring; he must be able to exercise a proper individual discretion in connection with the various irregularities encountered, and capable of a correct biological interpretation of the conditions met and data secured. Such competencies, it is self-evident, require a long preliminary preparation in anatomy, physiology, and other branches of science, as well as a practical course in measuring.

The best preparation for anthropometrical researches is found in the *ensemble* of medical studies; even these studies, however, are not sufficient until supplemented by a special anthropometric preparation.

A text-book instruction in anthropometry is not sufficient; it is the practical apprenticeship in the operatory technique of anthropometry which becomes more and more indispensable; this fact commences to be generally acknowledged.

Unnecessary modifications of simple and good instruments or methods are pernicious. It is possible to conserve and progress at the same time.

It is most important that ciphers obtained by one investigator should be comparable with those of others; if there be any personal errors resulting from the technique or other causes, there results only an apparent comparability, which is false in some particulars and leads to more or less considerable errors.

If the one who would measure lacks in the anatomical and physiological understanding of his work and its aims, his work should be regulated and overseen up to its minutest details by one who has such qualities.

The author ends his able paper by insisting once more upon the fact that "if a numerical expression of conditions, precious in all the sciences, can also occasionally be obtained with a sufficient accuracy in anatomy, respectively anthropology, it is only after a long theoretical, doubled by a technical, preparation of the investigator."

A. H.

The North Americans of Yesterday. — In an attractive volume Mr. F. S. Dellenbaugh [1] has described the Amerind race as it existed before the deterioration began from contact with the whites. The work is based upon a series of lectures delivered before the Lowell Institute of Boston in 1894. The author has adopted a "culture" rather than a "time classification"— in accordance with the present teachings of anthropology. In the introductory chapter popular errors regarding the character of the Amerind are pointed out and the fact emphasized that the whites surpassed them in cruelty. Popular contempt for the Amerind is largely due to ignorance.

Of a fairly uniform physical type, the Amerinds are divided into many linguistic stocks, "as remarkable for their separation in a body from the Old World languages as in their separation from each other." The development of so many languages and dialects must have required a long period of isolation; not only do we find a language for each group, but oftentimes a language for the priestly class and another for the people. By their picture-writing and hieroglyphs the Amerinds illustrate several stages in the development of written language. Southwest of the Sierra Nevadas painted characters are found; painted and scratched, from Colorado River to Georgia: elsewhere in America they are pecked or scratched. The order of development of written characters is, first, mnemonic; second, ideographic; third, phonetic. The last stage was within the grasp of the Mayan stock; they also had a well-developed numeral system.

Among the industrial arts that pertain to savagery basketry is one of the earliest developed, and the Amerinds were conspicuously successful as basket-makers. For the manufacture of pottery a

[1] Dellenbaugh, F. S. *The North Americans of Yesterday.* A Comparative Study of North-American Indian Life, Customs, and Products, on the Theory of the Ethnic Unity of the Race. New York, Putnams, 1901. 8vo, xxvi + 487 pp. over 350 illustrations.

somewhat more sedentary life is necessary, and we find the finest ware among the tribes having permanent settlements. That is, along the Atlantic coast fictile ware was crude and inartistic; in the Mississippi Valley and the Southwest it was of a superior quality. The art of weaving had been developed by many tribes before the Discovery, and a variety of costumes were worn. These are described in some detail, as well as the loom of the Navajos, who are now among the most successful aboriginal weavers. In carving, modeling, and sculpture the Mayas had accomplished results of no mean order. The author also has a word of praise for the carving of the Haidas of the northwest coast. He concludes that all was below the early achievements of the Egyptians. A very good description is given of the Amerindian dwellings and architecture. The range is very wide, from the simple brush shelter of the Pai Utes to the magnificent stone structures of Yucatan. The detailed description of the shelters and other structures shows the influence of environment upon this art.

All Amerinds were, in the stone age of culture, using also bone and wood for weapons. Copper was used but sparingly; bronze was known in Mexico, but not extensively used. Gold and silver were used for ornaments, especially in the South. The most important weapon was the bow and arrow; this is described at length, also the apparatus used in kindling fire. Domestic animals were wanting, and transportation by means of them impossible. Boats, however, were extensively used, and these are described. Other chapters are devoted to "Mining, Metallurgy, and Science"; "Musical Instruments, Music, Amusements, and Games"; "Works and Agriculture"; "Customs and Ceremonies"; "Myths, Traditions, and Legends"; "Organization and Government"; "Origin, Migrations, and History." Mr. Dellenbaugh believes that the tribes of the Northwest migrated there from the South and Southeast and not from the Asiatic direction. The earliest inhabitants of the New World came when there was a greater continuity of land surfaces than exists to-day and before there had been sufficient development of culture to indicate their relationships. The key to the Amerindian culture is the distribution of the glaciers. The earliest tribes came when the northern climate was mild; then, as the relations of land and water areas changed and the cold increased in the North, they were thrown more together and the groups that had begun to form reacted upon each other, tending again toward uniformity of type. The highest civilizations of the New World were developed at the

time of the glacial period, which our author believes to have been comparatively recent, — developed as a result of crowding on account of the habitable area being reduced. If the date of the glacier can be reconciled with that of the rise of Amerindian culture, this hypothesis is well reasoned.

The book is illustrated with several hundred plates from authentic and excellent photographs, chiefly from the collection of the Bureau of Ethnology. An appendix contains a complete list of linguistic stocks and a new list of the tribes. The whole forms a very readable popular treatise upon a generally misunderstood race that is fast passing away.

F. R.

BOTANY.

A Catalogue of North-American Plants. — Mr. A. A. Heller has published a second edition of his *Catalogue of North-American Plants.*[1] The catalogue is intended to be a complete list of the names of the Pteridophytes and Spermatophytes of the region included in the title, and which were published prior to October, 1900. The sequence of genera is that of Engler and Prantl's *Pflanzenfamilien*, the species being arranged alphabetically, and the most important synonyms given. A number of new combinations are published on pages 3 to 8, so we would not expect to find the first publication of names in the list, as was the case in Patterson's Check-List; but if some names have not been overlooked in the preparation of the catalogue, they appear to have been here for the first time suppressed.

It is hardly possible that such a work could be much more than a compilation, though the most recent authority seems to be followed, and no doubt some synonyms are included, and the contrary; also a few Mexican plants appear in the list.

The typography is very good and shows a decided advance over the first addition; but, considering the statement in the preface regarding the presswork, one would not expect to find as many errors as there are. The arrangement of the page is very neat and serviceable. Every other page is left blank for additions and corrections. The whole get-up of the book makes it very fit for use, and it will be exceedingly valuable, if not indispensable, to systematic workers.

The work is an indication of present taxonomic activity. The last species number in the 1898 catalogue was 14,534, and in the

[1] Heller, A. A. *Catalogue of North-American Plants North of Mexico, Exclusive of the Lower Cryptogams.* (2d ed.) 252 pp. 1900.

present one it is 16,673, plus 91 additions in the appendix, making an addition of over 2000 names in two and one half years.

J. B. S. N.

Notes. — The sixteenth volume of *Acta Horti Petropolitani* consists of an enumeration of the plants of the Caucasus collected in 1890 by Sommier and Levier. It forms a volume of 586 pages, illustrated by forty-nine lithographed plates.

Dr. Greene has begun the issuance of a new publication, *Plantæ Bakerianæ*, to be devoted to a series of lists of plants collected by Mr. Carl F. Baker and his colleagues, and distributed to various herbaria on both sides of the Atlantic. Mr. Baker is an enthusiastic, expert, and discriminating collector, who has made good specimens, and while all botanists may not go so far as Professor Greene is likely to in the division of species, those who possess the sets are likely to welcome the critical notes on them.

Judging from the appearance of Nos. 6, 7, and 8 of *Zoe* as a single signature without cover, under the belated date of February 6, the West Coast naturalists are not giving to this journal the measure of support that may have been hoped for when it was recommenced last year.

The second part of Vol. X of the *Transactions of the Connecticut Academy of Arts and Sciences*, lately distributed, contains a paper by Evans on the Hawaiian Hepaticæ of the tribe Jubuloideæ, and a paper by Sturgis on some type specimens of Myxomycetes in the New York State Museum.

Parts XIII and XIV of the current volume of the *Transactions of the Linnean Society*, issued in October last, consist respectively of supplementary notes on the genus Najas, by A. B. Rendle, and the comparative anatomy of certain species of Encephalartos, by W. C. Worsdell.

Fascicles 1 and 2 of the second volume of *Icones Selectæ Horti Thenensis* have been distributed.

Part IV of Dr. Rydberg's "Studies on the Rocky Mountain Flora" and Part V of Professor Piper's "New and Noteworthy Northwestern Plants," in the *Bulletin of the Torrey Club* for January, add a large number of species supposed to be new to science.

An important contribution to the pharmacognosy of Strophanthus seed, by Perrédès, is printed as No. 15 of the papers from the Wellcome Chemical Research Laboratory of London, of which Professor Power, formerly of the University of Wisconsin, is director.

The histological characters of senega root, as it occurs in the drug market, are discussed by Professor Sayre in the *Druggists' Circular* for February, and it is found that little structural difference exists between *Polygala Senega* and *P. alba*, from which it is derived.

In *Pittonia* for January Dr. Greene presents descriptions of a considerable number of newly differentiated species of various groups, and some interesting incursions into the genus Bidens.

Professor Sargent, in the *Botanical Gazette* for January and *Rhodora* for February, adds to the large number of species of Cratægus that are being described from this country.

An address on the cotton plant, by Dr. W. H. Evans, has been printed by the Cotton Manufacturers' Association.

A monograph of Melilotus, by O. E. Schulz, with fruit and other illustrations, is contained in Heft 5 of Vol. XIX of the *Botanische Jahrbücher.*

A monograph of the genus Siparuna, by Dr. Janet R. Perkins, as "Beiträge zur Kenntnis der Monimiaceæ, III," is separately distributed from Heft 5 of Vol. XXVIII of the *Botanische Jahrbücher.*

The genus Sophia, as it occurs in New Mexico, is analyzed by Cockerell in the January number of the *Bulletin of the Torrey Club.*

The first fascicle of Vol. XX of the *Mémoires de la Société Linnéenne de Normandie* consists mainly of a study of the structure and development of the conducting system in stem and leaf of the Nyctagineæ.

From a review of Jaennicke's papers on Platanus, in the *Botanisches Centralblatt* of February 13, it appears that the favorite shade tree known as *P. acerifolia* is regarded as a probable hybrid between the Old World plane, *P. orientalis*, and the American *P. occidentalis*, and not as a variety of the former, as has been commonly supposed.

Rather poorly printed reproductions of winter and summer photographs of a superb white oak are given in *American Gardening* for January 26.

An anatomical study of *Eriocaulon decangulare*, by Holm, appears in the *Botanical Gazette* for January.

The experiences, in Colombia, of a collector of *Odontoglossum crispum* are detailed by H. A. Sandback in *Gartenwelt* of January 19.

The cultivation of Agave in German East Africa is discussed by Hindorf in *Der Tropenpflanzer* for January.

Professor Lamson-Scribner, with the assistance of Mr. Merrill, has made an examination of the grasses of Elliott's Sketch of the Botany of South Carolina and Georgia, as represented in Elliott's herbarium, now in the possession of the College of Charleston, and the results constitute *Circular 29* of the Division of Agrostology of the United States Department of Agriculture.

The life-history of *Schizæa pusilla*, the smallest of our ferns which produces a protonema-like sexual generation, is discussed by Mrs. Britton and Miss Taylor in the *Bulletin of the Torrey Botanical Club* for January, which also contains the description of a new Adiantum of the Capillus-Veneris section, from New Mexico, by Dr. Underwood.

A number of fernwort papers, presented at a meeting of fern students held in New York, June 27, 1900, under the auspices of the Linnæan Fern Chapter, were issued in pamphlet form by W. N. Clute & Co., of Binghamton, on the 20th of December.

Among the Selaginellas of the rupestris group described as new by Hieronymus in the December issue of *Hedwigia* are several from the United States.

An ecological study of the New Jersey strand flora, by Dr. Harshberger, is reprinted from the *Proceedings of the Academy of Natural Sciences of Philadelphia* for 1900.

A flora of Lyon County, Iowa, by Professor Shimek, is separately printed from Vol. X of the *Annual Report of the Geological Survey* of that state.

"The Distribution of the Forest Trees of Iowa" is the title of a paper by Professor Shimek, reprinted from Vol. VII of the *Proceedings of the Iowa Academy of Sciences.*

An interesting forest study of anomalous growths of *Abies pectinata*, by Cavara, appears in the first fascicle of the current volume of *Le Stazioni Sperimentali Agrarie Italiane.*

"The Morphology of the Central Cylinder in the Angiosperms" is the subject of a paper by Dr. E. C. Jeffrey, reprinted from the *Transactions of the Canadian Institute*, illustrated by five calotype plates from photomicrographs.

The fall of leaves in Dicotyledons is considered by Tison in current numbers of the *Mémoires de la Société Linnéenne de Normandie*, and is illustrated by a large number of anatomical plates.

A condensed handbook of the diseases of cultivated plants in Ohio, by Professor Selby, constitutes *Bulletin 121* of the Agricultural Experiment Station of that state.

A note on Curare, by Bach, is contained in Vol. IV of the *Revista do Museu Paulista*, recently issued.

A portrait of Luther Burbank accompanies an otherwise illustrated article on his work in plant breeding, in *The Land of Sunshine* for February.

Drawing for process illustrations forms the subject of a practical illustrated article by Husnot, reprinted from Vol. III of the *Bulletin de la Société Linnéenne de Normandie*, which, while it may not be of much use to experts, ought to be studied by novices, — whose drawings are often the horror of editors who have to see them put into something printable.

An ecological study of the vegetation of Rio Grande do Sul, Brazil, by Lindman, has recently been published in Stockholm, under the auspices of the Royal Scientific Academy of that city.

The botanical appendix to Vol. XXV of the *K. Svenska Vetenskaps-Akademiens Handlingar* contains a number of papers dealing with South American botany.

No. 2 of Mr. Beadle's "Studies in Cratægus" is reprinted from the *Botanical Gazette* for November, and consists entirely of descriptions of species supposed to be new to science.

A new Helianthus from Florida, *H. agrestis*, is described by Pollard in the *Proceedings of the Biological Society of Washington*, under date of November 30.

The Podoclulinæ, a group of Indian orchids, are monographed by Schlechter in the *Mémoires de l'Herbier Boissier* of November 15.

A very useful key to the genera of Basidiomycetes of Vermont, with references to scattered literature for the determination of species in the several genera, published in 1899 by Dr. E. A. Burt, of Middlebury, has been republished recently, in a somewhat extended form, by the Boston Mycological Club.

Publication of a revised list of New Zealand seaweeds, by Laing, is begun in Vol. XXIII of the *Transactions of the New Zealand Institute*.

Seedlings, the study of which is now interesting a considerable number of persons, form the subject of a paper by Cockayne in the *Transactions of the New Zealand Institute* for 1899, recently issued.

Forestry receives another important contribution in the *Annual Report of the Geological Survey of New Jersey* for 1899, recently issued, which is supplemented by a series of large maps, and illustrated by over thirty well-done plates, many of them illustrative of forestry matters abroad.

A preliminary report on some diseases of New England conifers due to fungi, by Dr. von Schrenk of the Shaw School of Botany, is published as *Bulletin 25* of the Division of Vegetable Physiology and Pathology of the United States Department of Agriculture, and, like Dr. von Schrenk's earlier papers, is superbly illustrated from photographs.

A second part of Greshoff's memoir on plants used to stupefy fish has recently been published as No. 29 of the *Mededeelingen uit 's lands plantentuin* (of the Buitenzorg Botanical Garden). An idea of its extent may be obtained from the statement that the alphabetical index of the species noticed occupies thirty-nine double-column pages of large octavo size.

Part V of Dr. Greshoff's "Nuttige Indische Planten," completing the first volume, is issued as an *Extra Bulletin* by the Koloniaal Museum of Haarlem. It concludes with an alphabetical index to the fifty plates included in the volume.

An enumeration of the caoutchouc and guttapercha plants collected by Van Romburgh in Sumatra, Borneo, Riouw, and Java, by the late Dr. Boerlage, constitutes No. 5 of the *Bulletin de l'Institut Botanique de Buitenzorg.*

Dr. E. M. Wilcox reprints some readable "Glimpses of Tropical Agriculture" from a recent number of the *Columbus Horticultural Journal.*

Rheotropism forms the subject of an interesting paper by Berg in the *Acta Universitatis Lundensis* for 1899, recently received.

Professor Corbett, in the twelfth *Report of the West Virginia Experiment Station*, describes an important auxanometer and gives an account of some of the uses to which he puts it.

Zoe, in its new form, continues to be almost entirely botanical. Several interesting papers on West Coast botany occupy the double number for September–October.

A biographic sketch of the late Judge David F. Day, with portrait, appears in the *Botanical Gazette* for November.

PALEOBOTANY.

Elements of Paleobotany.[1] — The somewhat remarkable developments in the science of fossil plants which have taken place during the last decade receive renewed expression in the issue of an important work from the pen of R. Zeiller, already so well known to paleontologists for his extensive and admirable work on the fossil flora of France. In his *Éléments de Paléobotanique* M. Zeiller deals with fossil plants from the standpoint of the botanist conformably to modern views of botanical science. Though not so ambitious a work as Seward's *Fossil Plants*, the present work follows on similar lines with respect to general treatment of the subject, but treats of somewhat different types, thereby supplementing the former in important respects. It discusses

1. The mode of preservation of fossil plants.
2. Classification and nomenclature.
3. A systematic treatment of the various groups of plants, commencing with the Thallophytes.
4. The succession of floras and their relation to climatic conditions.
5. General considerations bearing upon the evolution of plant forms as indicated by the evidence of fossil plants.

Probably the most striking feature of the book is the recognition which it gives to Pontonié's Cycadofilices, a group of plants now definitely recognized as occupying an important and intermediate position between the ferns and the cycads — a fact which serves to bring into conspicuous relief the important nature of the recent developments of paleobotanical science. The work is valuable and suggestive, and will find a ready welcome on the part of botanists.

D. P. P.

Notes. — The material dealt with by David White (*Nineteenth Ann. Rept. U. S. Geol. Surv.*, Pt. III) in his report on the "Fossil Plants from the McAlister Coal Field, Indian Territory," furnishes essentially the first paleobotanical data respecting the Carboniferous of the regions southwest of Kansas, and it therefore affords the first instance relative to the vertical range and distribution of the Northern Coal Measures within the southwestern portion of the western interior basin, supplying an important basis for the correlation of

[1] Zeiller, R. *Éléments de Paléobotanique.* Paris, Carré et Naud, 1900. 8vo, 417 pp., illustrated.

the plant-bearing series of that region with the Coal Measures in other parts of the United States. In all, sixty-nine forms or species are represented. The types of Mariopteris, Neuropteris, and Pecopteris are especially abundant and prominent, while the relatively small percentages of species common to the two stages show that there are marked differences between the floral characters of the three stages represented in the McAlister coal field.

Recent studies by David White (*Bull. Geol. Soc. Amer.*, Vol. II, p. 145) present an interesting discussion of the relative ages of the Kanawha and Allegheny series, and afford an excellent illustration of the value of correctly interpreted paleobotanical data in determining the age of deposits.

The latest contribution to our knowledge of that remarkable collection of Mesozoic cycads now to be found in the Yale Museum is from the pen of Professor L. F. Ward (*Amer. Journ. Sci.*, Vol. X, p. 327), who details the history of the 731 specimens there brought together, and adds to his previous lists descriptions of seven new species embraced in hitherto unclassified material.

D. P. P.

PUBLICATIONS RECEIVED.

(Regular exchanges are not included.)

BOHN, Z. L'Évolution du Pigment. *Scientia*, No. 11. Paris, Carré et Naud, 1900. 96 pp., 8vo. 2 francs. — COULTER, J. M., and CHAMBERLAIN, C. J. Morphology of Spermatophytes. New York, Appleton, 1901. x, 188 pp., 8vo, 106 figs. $1.75. — GOOD, GEORGE BROWN, A Memorial Volume of, together with a Selection of his Papers on Museums and on the History of Science in America. *Annual Rept. Smith Inst. Nat. Mus.* Pt. ii. xii, 515 pp., 106 portraits. — GRIFFIN, E. L'Assimilation Chlorophyllienne et la Structure des Plants. *Scientia*, No. 10. Paris, Carré et Naud, 1900. 106 pp., 8vo, 34 figs. 2 francs. — SEWARD, A. C. Catalogue of the Mesozoic Plants in the Department of Geology, British Museum. (Natural History: The Jurassic Flora. I. The Yorkshire Coast.) xii, 341 pp., 8vo, 21 pls., 53 text-figs.

COE, W. R. Papers from the Harriman Alaska Expedition. XX. The Nemerteans. *Proc. Wash. Acad. Sci.* Vol. iii, pp. 1–110, Pls. I–XIII. — COQUILLETT, D. W. New Diptera in the U. S. National Museum. *Proc. U. S. Nat. Mus.* Vol. xxiii, pp. 593–618. — DALL, W. H. Results of the Brauner-Agassiz Expedition to Brazil. V. Mollusks from the Vicinity of Pernambuco. *Proc. Wash. Acad. Sci.* Vol. iii, pp. 139–147. — ELLIOT, D. Z. List of Mammals obtained by Thaddeus Surber, Collector for the Museum in the Provinces of New Brunswick and Quebec, Canada. *Field Columbian Museum, Zoöl. Ser.* Vol. iii, No. 3, pp. . — ELLIOT, D. Z. Synopsis of the Mammals of North America and the Adjacent Seas. *Field Columbian Museum, Zoöl. Ser.* Vol. ii. xv, 471 pp., 94 figs. — FARRINGTON, O. C. Observations on Indiana Caves. *Field Columbian Museum, Geol. Ser.* Vol. i, No. 8, pp. 247–266, Pls. XXXII, XXXIII, and 9 figs. — HERSHEY, O. H. The Geology of the Central Portion of the Isthmus of Panama. *Univ. Cal. Bull. Dept. Geol.* Vol. ii, No. 8, pp. 231–267, map. — HOLM, T. Fifth List of Additions to the Flora of Washington, D. C. *Proc. Biol. Soc. Wash.* Vol. xiv, pp. 7–22. — MERRIAM, C. H. Two New Big-horns and a New Antelope from Mexico and the United States. *Proc. Biol Soc. Wash.* Vol. xiv, pp. 29–32. — MILLER, J. S. A New Squirrel from Borneo. *Proc. Biol. Soc. Wash.* Vol. xiv, pp. 33, 34. — MILLER, J. S. Mammals Collected by Dr. W. L. Abbott on the Natuna Islands. *Proc. Wash. Acad. Sci.* Vol. iii, pp. 111–138. — PRICE, R. H. Pruning and Training Peach Orchards. Texas Agr. Exp. Sta., *Bull. No. 58.* Pp. 27–42, 15 figs. — RIDGWAY, R. Results of the Agassiz-Brauner Expedition to Brazil. V. New Birds of the Families Tarragidæ and Scteridæ. *Proc. Wash. Acad. Sci.* Vol. iii, pp. 143–155. — SHUFELDT, R. W. Osteology of the Herodiones. *Annals Carnegie Mus.* Pp. 158–249, Pls. V, VI, and 43 figs. — STONE, W., and DUTCHER, W. Report of the Committee on Protection of North American Birds for the year 1900. *Cent.* January, pp. 68–104. — THOMAS, O. A New Spiny Rat from La Guaria, Venezuela. *Proc. Biol. Soc. Wash.* Vol. xiv, pp. 27, 28. — TOUMEY, J. W. An Undescribed Agave from

Arizona. *Report Missouri Botanical Garden.* Vol. xii, pp. 75, 76, Pls. XXXII, XXXIII. — TRELEASE, W. A Cristate Pellaea. *Report Missouri Botanical Garden.* Vol. xii, p. 77, Pl. XXXIV. — TRELEASE, W. A Pacific-Slope Palmetto. *Report Missouri Botanical Garden.* Vol. xii, pp. 79, 80, Pls. XXXV–XXXVII. — WASHBURN, F. L. Sanitary Biology: Analysis of Drinking Water. *Report State Biologist Oregon.* 11 pp., 3 pls. — WHITNEY, A. W. Evolution and the Theory of Probability. Contributions from the Botanical Seminary, University of California. *No. 3 Univ. Chronicle.* Vol. iii, pp. 402–421.

Annales del Museo Nacional de Montevideo. Tome ii, Fasc. xvii, xviii. — *Bulletin Johns Hopkins Hospital.* Vol. xii, Nos. 119, 120. February and March. — Entomological Society of Ontario. *Thirty-first Annual Report.* 112 pp., 46 figs. — *Johns Hopkins Hospital Reports.* Vol. viii, Nos. 3–9. — *Memorias y Revista Sociedad Cientifica "Antonio Alzate."* Tome xv, Nos. 1, 2. — *Modern Medicine.* Vol. x, No. 3. March. — *Revista Chilena de Historia Natural.* Año v, No. 1. January.

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THE COMPOUND AND MIXED NESTS OF AMERICAN ANTS.

WILLIAM MORTON WHEELER.

PART II. THE KNOWN CASES OF SOCIAL SYMBIOSIS AMONG AMERICAN ANTS.

SOCIAL symbiosis among ants occurs in what are called "compound" and "mixed" nests. These terms are used in the sense of Forel's "fourmilières doubles" and "fourmilières mixtes." The former are defined ('**74**, p. 52) as "nests inhabited simultaneously by two or more ant colonies belonging to two or several hostile species." The latter term was adopted by Forel from Pierre Huber ('**10**). It includes the nests which are amicably inhabited in common by ant colonies belonging to different species. Both categories were later accepted by Wasmann ('**91**) with slight changes, and, somewhat more accurately, designated as "zusammengesetzte Nester und gemischte Kolonien" (compound nests and mixed colonies). Wasmann included all the various forms of compound and mixed nests known in 1891 in the following table ('**91**, pp. 176–178):

"*A.* Compound Nests (*zusammengesetzte Nester*). The consociating ants maintain independent households, or *ménages; i.e.*, constitute separate colonies. This form of symbiosis occurs between ants belonging either to the same or to different subfamilies.

I. Accidental (*i.e.*, Occasional) Forms:

1. Nests established in close proximity to each other by ants which have certain predatory proclivities. Examples: *Tetramorium cæspitum* with *Formica sanguinea*; *Dorymyrmex pyramicus* with *Pogonomyrmex barbatus*.
2. Nests established in close proximity to each other, with the subsidiary object of securing comfortable, warm, and secure quarters. Examples: *Formica fusca* and *Myrmica ruginodis* with *F. rufa* and *pratensis*; *Leptothorax muscorum* under the bark of pine trunks surrounded by *rufa* nests; *Myrmecina latreillei* Latr. with *F. rufa* and *exsecta*.

II. Regular Forms:

1. Thief ants: *Solenopsis fugax* and *Solenopsis orbula* with ants of much greater size.
2. Guest ants: *Formicoxenus nitidulus* with *Formica rufa* and *pratensis*; *Xenomyrmex stollii* with *Camponotus abscisus*.

B. Mixed Colonies (*gemischte Kolonien*). The different consociating ants carry on a single household, thus constituting a single colony. This form of symbiosis occurs only between ants belonging to the same subfamily.

I. Normal (*i.e.*, Regular) Forms:

1. The dominant species has its own workers, with toothed mandibles. Colonies clearly of predatory origin. *Formica sanguinea* ♂ ♀ ☿ and their developmental forms ⌓[1] workers and worker pupæ of *F. fusca* or *rufibarbis* or both, or of *F. schaufussi* or *fusca* (in North America).
2. The dominant species has its own peculiar workers without toothed mandibles.
   a. The dominant species is represented by ♂ ♀ ☿ and their developmental stages, the auxiliaries only by the workers and their pupæ. Predatory colonies:
      α. Colonies clearly predatory in origin: *Polyergus rufescens* ⌓ *F. fusca* or *rufibarbis* (or very rarely both), *Polyergus lucidus* ⌓ *F. schaufussi*.
      β. Colonies probably of predatory origin: *Strongylognathus huberi* ⌓ *Tetramorium cæspitum*.

[1] The sign ⌓ is used to express the union of two species to form a single colony. The name of the auxiliary (slave) species is always placed after the sign.

b. The dominant species is represented by ♂ ♀ ☿ and their developmental stages, the auxiliaries by the workers and their developmental stages and by fertilized females. Colonies arising by affiliation (*Bundescolonien*): *Strongylognathus testaceus* ⩭ *Tetramorium cæspitum.*

c. The dominant species appears to be represented only by the ☿ and its developmental stages, the auxiliaries by ♂ ♀ ☿ and their developmental forms.[1] Probably predatory colonies, which, however, do not arise like the above through the robbing of the pupæ of strange nests, but by the dominant species driving out the latter and taking possession both of their nest and brood. *Tomognathus sublævis* ⩭ *Leptothorax acervorum* or *muscorum.*

3. The dominant species has no worker form: *Anergates atratulus* ♂ ♀ and their developmental stages ⩭ *Tetramorium cæspitum* (workers only). Perhaps these colonies might be more conveniently designated as guest colonies.

II. Accidental (Abnormal) Forms:

1. Artificial mixed colonies arising through affiliation. Examples: *Formica sanguinea* ⩭ *pratensis*; *F. rufa* ⩭ *pratensis*; *Polyergus rufescens* ⩭ *rufa.*

2. Artificial mixed colonies of predatory origin:

a. Produced in confinement: *F. sanguinea* ⩭ workers of *fusca* or *rufibarbis* (normal auxiliaries); *rufa*, *pratensis*, *cinerea*, *exsecta*, *pressilabris* (abnormal auxiliaries).

b. Occurring in a state of nature: *F. sanguinea* ⩭ workers of *fusca* and *pratensis* or *rufibarbis* and *pratensis.*

3. Natural, abnormal, mixed colonies:

a. Unusual auxiliaries, with the usual dominant species. Predatory colonies:

Form. sanguinea ⩭ workers of *pratensis.*
" " " " " *rufa.*
" " " " " *rufa* and *fusca.*

b. Usual auxiliaries, with an unusual dominant species. Colonies probably arising by affiliation: *F. pratensis* ⩭ *fusca*, *truncicola* ⩭ *fusca*, *exsecta* ⩭ *fusca.*

c. Neither species living, as a rule, with other ants, either as auxiliaries or as dominant species: *Tapinoma erraticum* ⩭ *Bothriomyrmex meridionalis.*

[1] This assertion now requires modification, since Adlerz has published his later observations ('96).

C. Various combinations of the regular and irregular types of compound nests and mixed colonies. Examples: *Solenopsis fugax* with *Formica sanguinea* = *fusca*; *Tomognathus* = *Leptothorax* with *F. rufa*."

While this table leaves little to be desired in point of logical construction, it is scarcely an adequate expression of the facts at the present time. Nor could this be expected, as a decade has elapsed since its publication. It seems worth while to replace it by a number of coördinated categories, for two reasons. First, the case of *Leptothorax emersoni*, described in the first part of this paper, is in certain respects clearly transitional between Forel's and Wasmann's leading categories of compound and mixed nests, so that the dignity of these main groups is thereby considerably impaired. Second, the various cases of compound and mixed nests obviously represent several independent and more or less divergent lines of phylogenetic development, as Wasmann has shown ('**91**, p. 239). Hence it seems advisable to attempt a natural grouping of the cases, even at the expense of multiplying categories. I have, therefore, adopted the following headings, which may be cited with their equivalents in Wasmann's table:

I. *Plesiobiosis.* Double nests (in Forel's sense); Wasmann's accidental forms of compound nests. (*A* I, 1 and 2.)

II. *Parabiosis.* (Forel '**99**) Not included in Wasmann's table.

III. *Cleptobiosis.* Wasmann's "Diebsameisen"; first regular form of compound nest. (*A* II, 1.)

IV. *Xenobiosis.* Inquilines, or guest ants; Wasmann's "Gastameisen"; second regular form of compound nest. (*A* II, 2.)

V. *Dulosis.* Slavery. ("Esclavagisme," Forel.) Wasmann's normal forms of mixed colonies. (*B* I, 1 and 2.)

VI. *Colacobiosis.* Social parasitism (Forel); Wasmann's third case of normal mixed colonies. (*B* I, 3.)

VII. *Synclerobiosis.* Mixed nests of uncertain origin and meaning. Wasmann's last case (*B* II, 3 *c*) of accidental (abnormal) mixed colonies.

Although of considerable interest, the artificial mixed colonies (Wasmann's *B* II, 1 and 2) are omitted in this scheme, because they are mere beginnings in a field of experiment that has been little cultivated in Europe and is still untouched in America. It might be possible to include them with the cases of synclerobiosis. The natural abnormally mixed nests (Wasmann's *B* II, 3 *a*) are best treated in connection with the normal cases of dulosis. Combinations of regular and irregular mixed and double nests (Wasmann's category *C*) are rather rare and exceptional, and may be placed as compounds of the simpler relations under some one of the seven headings above enumerated.

I. Plesiobiosis.

As restricted in the present paper, plesiobiotic, or double nests comprise only those cases in which two, or rarely more, colonies of ants of different species excavate their galleries in close contact with one another. They are usually established under stones or logs, but a peculiar group of such nests is formed by several species that live within the precincts of the huge, exposed, mound-like nests of the agricultural ants (species of Pogonomyrmex). The colonies inhabiting double nests are usually inimical, or at best indifferent to one another. Hence, when living under stones or in old logs, they very carefully wall up the intervening space, so that the galleries belonging to the two households cannot inosculate.

Two classes of double nests may be distinguished. One of these embraces a vast series of merely accidental associations of two (or, more rarely, more) species. The associations of the other class are claimed to occur with a certain regularity and frequency, as if one or both of the species concerned were settling into definite and constant symbiotic relations. The cases of the former class are of comparatively little interest, except in so far as they represent what must have been the very first step in the development of the more specialized unions (xenobiosis, dulosis, colacobiosis, etc.). Any attempt at cataloguing these various associations would be unprofitable, if not impossible. As an illustration of such cases, it may suffice to

mention, in passing, one very beautiful example. On March 9 of the current year I found two double nests under large stones on opposite sides of a road near Austin, Texas. The ants were in both cases the huge black Ponerine *Pachycondyla harpax* and the fine honey-yellow *Camponotus fumidus*, var. *festinatus* (=*Formica festinata* Buckl.). In each case the latter species had excavated its nicely finished galleries and chambers under the middle of the stone, while the former had extended its few broad and irregular burrows along the surface so as nearly to encircle the Camponotus nest. The contrast between the color of these large ants, the one belonging to the most primitive, the other to the most specialized subfamily of the Formicidæ, was scarcely greater than that exhibited by their architecture. As soon as the nests were uncovered the Camponoti sniffed the presence of their black neighbors and hastily retreated into their galleries; while the Ponerinæ seemed as oblivious of their fellow-tenants as the occupants of a Chicago apartment building. Similar nests of *P. harpax* and *C. maculatus*, subsp. *sansabeanus*, are not infrequent in the neighborhood of Austin, but these, too, are merely accidental associations, as all three of the species mentioned are nearly always found occupying single nests.

The second class of plesiobiotic colonies, *viz.*, those which have been considered by some authors as incipiently symbiotic, really represent very little advance on cases like those above described. I am convinced that the supposed regularity of these associations may be largely the result of hasty or inadequate observation. In several instances the two species of ants are quite as often, or even more frequently, found in single nests. Usually one of the species is of diminutive size, and this has led observers to suppose that they were dealing with a small and feeble ant living under the wing of a formidable neighbor. It is, however, quite as probable that the two species occur together, because both affect the same natural conditions, such as soil, moisture, presence or absence of vegetation, etc. This is noticeably the case with Pogonomyrmex and its various satellites.

1. **Myrmecina graminicola** Förster.

Myrmecina graminicola (*M. latreillei* Curt.) is a small, rather rare ant, occurring both in Europe and North America. On our continent it is represented by two subspecies — *americanus* Emery, with its variety *brevispinosus* Emery, and a second undescribed subspecies recently discovered in Texas.

The habits of the European Myrmecina have been observed by Forel ('**74**, pp. 352–353). He found it living in small colonies under stones. It is rather sluggish and cowardly. When disturbed, instead of defending itself or running away like most other ants, it relies on the protection afforded by its very hard integument, rolls itself up in a ball and "feigns death." Forel found that it would not attack *Tetramorium cæspitum* or *Strongylognathus huberi*, even when these ants invaded its nest. The European Myrmecina is described as having a *penchant* for forming double nests with other ants. One of the two colonies found by Forel was near a nest of *Formica rufa*, the other near a nest of *Ponera coarctata*. Wasmann ('**91**, p. 176, footnote) also found a Myrmecina colony in a nest of *Formica exsecta*.

So far as I have been able to observe, our American subspecies appear to have the same habits as the European form. A few specimens of the new subspecies found at Austin were under a stone which covered besides a small colony of *Formica subsericeo-neorufibarbis* Emery (= *F. gnava* Buckl.). Two nests of the subspecies *americanus*, variety *brevispinosus*, found at Colebrook, Conn., during the past summer, were associated with *Stenamma fulvum*, subsp. *aquia* Buckl., and *Ponera coarctata*, subsp. *pennsylvanica* Buckl.

2. **Leptothorax muscorum** Nylander.

According to Emery ('**95**, p. 318), *Leptothorax muscorum*, like Myrmecina, occurs in the United States as well as in Europe, but nothing is known concerning its habits in the former locality. In Sweden, according to Adlerz ('**86**, p. 210), it has a decided proclivity for living within the confines of *Formica rufa* nests. Both Adlerz and Wasmann ('**91**, p. 225) lay stress

on this peculiarity as representing a decided step towards the conditions exhibited by the guest ant, *Formicoxenus nitidulus* (*q.v.*). It is of even greater interest in connection with the habits of its congener, *L. emersoni*.

3. **Monomorium minutum** Mayr., var. **minimum** Buckley.

This widely distributed ant forms small but very populous nests, containing from one to a dozen or more deälated queens and hundreds or even thousands of workers. It is very common under stones in the open cedar brakes in many places about Austin, Texas. Usually its nests are solitary, but it frequently forms double nests with the larger ants of the vicinity. I have often found it with *Camponotus maculatus*, subsp. *sansabeanus*; *C. fumidus*, var. *festinatus*; *Formica subsericeo-neorufibarbis*; *Pachycondyla harpax*; and under small stones on the summits of the nest-cones of *Pogonomyrmex barbatus*, var. *molifaciens* Buckl. The large ants are assailed with fury when the nests are disturbed and they accidentally stumble into the galleries of the Monomorium. These minute black ants, however, are not altogether averse to the society of other ants, as is shown by their forming mixed nests with two interesting species to be considered below, *viz.*, *Leptothorax* (*Dichothorax*) *pergandei* Emery and *Epœcus pergandei* Emery.

4. **Forelius fœtidus** Buckley (= **Forelius mccooki** Forel).

Attention was first directed to this small, dull yellowish dolichoderine ant by McCook, who found it living amicably within the nest boundaries of the Texan agricultural ant (*Pogonomyrmex barbatus*, var. *molifaciens*). The substance of his observations is contained in the following remarks ('79, p. 202): "Numbers of these ants were frequently seen traveling in long lines across or near to the nest of Barbatus (Pl. XXIV, Fig. 118). Usually their route was established upon blades of grass growing on those nests which were covered with the Aristida, or along the low tufts of grass on the margin of the disk. They seemed to prefer this elevated transit to moving directly upon the surface, which they touched only

when a break in the herbage compelled them to descend. They traveled in single, or 'Indian' file, one behind another. . . . The specimens which I preserved were taken from a small colony found within the bounds of a large Barbatus formicary which was being excavated. The agriculturals took no notice of their tiny neighbors, at least never interfered with them, and the two species seemed to be upon the most friendly terms with each other."

McCook's observations are, in the main, correct, so far as they go, but they are so incomplete as to give a wrong conception of the habits of Forelius. This ant is extremely common at Austin, where McCook made the above-quoted observations. It really prefers dry soil, nearly or quite destitute of vegetation. It throws up its little crater-shaped mounds of earth in great numbers along the paths and roads, and on warm sunny days travels in straggling files over all the barren lands. Sometimes, however, it nests under stones on the dry hillslopes, and it is in such situations that one often finds the largest and most flourishing colonies, containing many deälated queens and thousands of workers, larvæ and pupæ. The fact that it often builds within the confines of the Pogonomyrmex formicaries is easily explained, for, though the agricultural ant naturally prefers grassy regions, nevertheless, through its singular habit of clearing away the vegetation over a large circular area, it establishes the very conditions that are preferred by the Forelius. The "friendly relations" with Pogonomyrmex are perhaps to be explained by the very small size and active movements of Forelius, which thus escapes the attention of its huge neighbors. In this respect the dolichoderines seem to be in the same position as the small white podurans (Cyphodeira), which run about unheeded in the galleries and chambers of the Pogonomyrmex nests.

5. **Dorymyrmex pyramicus** Roger.

In connection with some rather fanciful passages from the manuscript of Lincecum, McCook ('**79**, p. 197 *et seq.*) records several observations of his own on the relations of *Dorymyrmex*

pyramicus to *Pogonomyrmex barbatus*. Though the former ant, which ranges from Colorado and North Carolina to the Argentine Republic, is not uncommon at Austin, I have not often observed it in this locality. But I have found its small earthen mounds in very great numbers about Aguas Calientes in Mexico. Here it occurs quite as frequently outside as within the formicary boundaries, both of the typical *P. barbatus* and its variety, *molifaciens*. Like Forelius, Dorymyrmex is an ant of the barren soil, and its occurrence within the formicary precincts of the agriculturals is probably open to the same explanation. It is, however, far more pugnacious than Forelius, and, though tolerated by Pogonomyrmex, it resents any intrusion on the part of its larger neighbors. Both Forelius and Dorymyrmex, like many other dolichoderines, emit a rank secretion, which is in all probability protective.

6. **Dorymyrmex pyramicus** Roger, var. **flavus** McCook.

According to McCook ('**82**, pp. 155–158), this variety occurs with *Pogonomyrmex occidentalis* Cresson in Colorado. "There was scarcely a formicary which came under observation, from first to last, that had not upon the clearing one or more colonies of the erratic ant, *Dorymyrmex insanus* Buckley, or a new species of variety, *D. flavus* McCook. Usually there are two or three nests, sometimes four, located upon different parts of the pavement. These are small moundlets of fine soil, surrounding a central opening which leads into an irregular series of galleries and chambers. The same insects are parasitic upon the disks of the agricultural ants of Texas, and exhibit there characteristics similar to those in the Garden of the Gods. They are small, very active, irritable, intensely pugnacious, and courageous to the last degree. The manner in which these little fellows bullied and badgered their occident hosts was amusing, and indeed amazing." Nests of *Dorymyrmex pyramicus*, var. *flavus*, are rather common at Austin, but as yet I have failed to find them within the Pogonomyrmex formicaries, although I have no doubt that they occasionally occur in such situations.

7. **Pheidole carbonaria** Pergande, subsp. **calens** Forel.

At Aguas Calientes, Mexico, I observed several nests of this small, timid Pheidole on the slopes or about the bases of the beautiful gravel cones of the typical *Pogonomyrmex barbatus*, and its variety, *molifaciens*. The Pheidole was not found elsewhere in the vicinity, but my stay was too brief to enable me to assert that this ant really exhibits a more definite association with Pogonomyrmex than that of Forelius and Dorymyrmex. From the appearance of its soldiers, *Pheidole carbonaria* would seem to be a seed-storing species like our Texan *Pheidole kingi* André, var. *instabilis* Emery, and the Northern *Pheidole pilifera* Roger (= *pennsylvanica* Roger). If this is true, the Mexican insect may be a thief-ant feeding on the seed stored by the agriculturals in their large chambers, which are often sufficiently near the surface of the mounds to be invaded by small ants.

8. **Formica sanguinea** Latr.

McCook ('82, p. 152) found colonies of *Formica sanguinea*, with their slaves, within the clearings of three different nests of *Pogonomyrmex occidentalis* in Colorado. These and several other ants appeared to be tolerated in this situation by the occident ants. Such observations show that the association of ants with the Pogonomyrmex cannot be in all cases prompted by a desire for greater protection, since *F. sanguinea* is a bold, predaceous species, quite capable of making its way independently. It also shows that the formicary precincts of the agricultural ants may be open to some intruders of considerable size. Experience has taught me that it is not an easy matter to determine the attitude of these ants towards other animals. This is evident from the following jottings from my notebook: *Pogonomyrmex barbatus* sometimes permits the leaf-cutting ants (*Atta fervens*) to wear a groove-like path diagonally across its disk. It will also allow large tenebrionid beetles (*Eleodes tricostatus*), often to the number of six or eight, to stalk about for hours unmolested on its nest, and to feed on the refuse vegetable matter accumulated within the confines of

the pavement or even on the gravel cone.[1] On the other hand, I have counted on a single pavement no less than ten of the balls of dung abandoned by the Canthons (*C. lævis*) which had been driven away from their precious charges by the ants. Malodorous beetles like *Chauliognathus scutellaris* when placed on the nests are seized by the ants, at once carried to the edge of the pavement, and dumped over the boundary. Man and the larger domestic animals are soon attacked when they stand within the disk, and the horned toad, which seems to feed very largely on these ants, is treated in the same manner. (See Edwards, '96.)

II. PARABIOSIS.

Forel ('99) introduced the term "parabiosis" to designate a peculiar form of compound nest with inosculating galleries, in which different species of ants have their households strangely intermingled but not actually blended. Only one typical case of this description is known, but some remarkable nests in tillandsias recently observed by me in Mexico are in certain respects similar to the case described by Forel, so that they may be included, at least provisionally, in the same category.

9. Dolichoderus and Cremastogaster.

The interesting observations made by Forel ('99, pp. 380, 381) in the United States of Colombia during the spring of 1896 are here translated in full:

"I frequently observed, originally in the neighborhood of Santa Martha, two species of ants belonging to different genera and even subfamilies, a Dolichoderus and a Cremastogaster, both shining black, the former very large, noticeably larger than the latter, usually running in the very same files, both over the ground and on the trees and undergrowth, in the most perfect amity. The files were very long and dense, so that the ants met and elbowed one another continually. The two species went foraging on the trees, the Cremastogaster searching mainly for plant lice and Coccidæ, the Dolichoderus

[1] Several years ago I observed another species of Eleodes similarly engaged on the nests of *P. occidentalis* in Wyoming.

for the sap of the plants. For this reason the files bifurcated towards their ends, each species going to its own destination. I finally discovered in the trunk of a mango a large termite nest which had been appropriated by the two species of ant under discussion, and served them as a common dwelling in a manner hitherto unknown. The time was decidedly propitious, as each species had its winged sexes and its pupæ in the nest. The nest was inhabited as it had been left by the termites without additions or alterations. In no portion of the nest was there a blending of the two species of ants. Some of its corners were still tenanted by the termites. But the chambers and galleries throughout nearly their whole extent were occupied either by the Cremastogaster with their females, males, and pupæ, or by the Dolichoderus with the corresponding sexes and developmental stages. Each species had its own household, in contradistinction to the mixed formicaries of our Polyergus and Formica, which have but a single household in common. But all the chambers and galleries inhabited by one of the two species communicated freely with the cells tenanted by the other, and, as if intentionally, the apartments of one were interlaced with those of the other. Instead of one species taking possession of one-half of the nest, and the other of the remainder, they interdigitated throughout, so that there was not a piece of the nest as large as an egg which did not contain both species. The whole nest was about four or five decimeters in diameter. Thus the case is altogether different from that of the double or compound nests in Europe, where two or several inimical species may have their galleries interlacing to some extent but not inosculating. In this case we are concerned with an amicable association for lodging and for the files, which go foraging together, but without actually blending, so that the two species lead an independent life side by side. Hence the term 'parabiosis' which I have thought best to apply to this kind of association. It should be remarked, however, that the parabiotic association of these two species is not constant, though very frequent. I have also found the nest of each species by itself." [1]

[1] In conclusion Forel calls attention to the fact that some birds exhibit a similar parabiosis, *e.g.*, the joint flocks of *Corvus cornix* and *C. corone* in Europe.

10. *Nests in Tillandsias.*

On December 27 of the past year, while collecting ants in a small grove at the head of one of the *barrancas* near Cuernavaca, Mexico, I happened on some peculiar nests, concerning which I can find no account in the literature. After collecting a number of species under the stones, I turned my attention to the limbs and foliage of the acacia and guava trees overhead. On accidentally pulling to pieces one of the large bud-like epiphytic tillandsias (probably *Tillandsia benthamiana* Klotzsch), very common both in this and other localities about Cuernavaca, I was surprised to find it containing whole nests of ants, with their larvæ and pupæ snugly packed away like so many anchovies in the spaces between the moist overlapping leaves. A closer inspection showed that the ants had gnawed little holes through the leaves to serve as entrances to their chambers. These holes occasionally perforated a single leaf, but quite as often they threaded several leaves and extended to the very core of the bud. Sometimes a single colony of ants was divided up into companies, each occupying the space under a single leaf. But the most remarkable fact concerning these nests was the frequent occurrence of two or even three flourishing colonies belonging to different species in a single tillandsia, the whole habitable basal portion of which was rarely more than 2–3 inches long by 1½ inches in diameter. Often these colonies were curiously intermingled in such a manner that though there was no actual blending and the space under a single leaf was always occupied by ants of the same species, still, whole colonies or portions of a single colony were often completely surrounded by leaf spaces occupied by another colony. During the few hours which I could devote to collecting, the following seven species — three of them new to science, as Professor Forel informs me — were taken from the tillandsias:

1. *Cremastogaster brevispinosa* Mayr., var. *minutior* Forel.
2. *Camponotus abdominalis* Sm., subsp. or var. between *esuriens* Sm. and *mediopallidus* Forel.
3. *Camponotus rectangularis* Em., var. *rubroniger* Forel.

4. *Cryptocerus aztecus* Forel.
5. *Cryptocerus wheeleri* Forel.
6. *Leptothorax petiolatus* Forel.
7. *Pseudomyrma gracilis* Fabr., var. *mexicana* Em.

Of these species, which are here enumerated in the order of decreasing frequency, — the first being far and away the most abundant, — I noticed the following combinations occurring in single buds: Nos. 1 + 2; Nos. 1 + 2 + 4; Nos. 1 + 3 + 4; Nos. 1 + 5 + 6; Nos. 1 + 7.

While I am not certain that the nests of the different species could communicate with one another, I am confident, nevertheless, that these ants must be very tolerant of one another, for their entrances were situated on such a small surface as to be of necessity very close together. This is the more astonishing on account of the great diversity of behavior exhibited by the different species. When I was tearing the leaves asunder the little Cremastogasters attacked me vigorously, but their lilliputian stings and mandibles could scarcely perforate my epidermis. The huge *Camponotus abdominalis*, however, rushed out in a body, and the powerful mandibles of the soldiers, reinforced by the copious formic acid batteries of the whole company, often compelled me to drop the tillandsia and forego further exploration of its leaves. The two species belonging to the grotesque genus Cryptocerus were as gentle as lambs, preferring to rest quietly on my hands and clothing. The timid little Leptothorax took to their legs, while the superb wasp-like Pseudomyrmas made dashes at me from among their glistening larvæ and pupæ, but returned with precipitation as if afraid to abandon their offspring.

As the tillandsias appeared to suffer no injury from their tenants, and were even preparing to send forth their long spikes of reddish flowers, I was at first inclined to see in this association of plants and ants another case of symbiosis (*sensu stricto*). But apart from v. Ihering's contention ('94 p. 365 *et seq.*) that the number of "Ameisenpflanzen" in tropical America has already been considerably exaggerated, the above view also loses in probability from the fact that at least four of the seven

species which I have enumerated occur also under other conditions in the neighborhood of Cuernavaca. Nos. 1, 2, 3, and 7 were found nesting in the dead trunks and branches. No. 2 also nests under stones, and it is probable that 4, 5, and 6, at least occasionally, nest in dead wood, like many other species of the same genera in other regions. The little Cremastogaster uses a black, paper-like substance for constructing perforated partitions within the spaces which it inhabits and for closing up the openings left at the tops of the chambers by the slightly divaricating leaves of the tillandsia. A colony of this species was also found inhabiting the cup-like cavity of one of the peculiar flower-like excrescences on the branches of the guava trees — the "flores de guavera" of the inhabitants of Cuernavaca. The ants had closed the wide orifice of the cup with a layer of the black papery substance and had left a small opening near its center to serve as an entrance. The relations of the ants to the tillandsia would seem, therefore, to be very similar to those often formed by several other species with empty galls and hollow thorns, both in Mexico and other countries. These relations are of great interest as one of many expressions of the remarkable plasticity of instinct in these insects.

Living colonies of *Cremastogaster brevispinosa* and *Cryptocerus aztecus* were brought back to Austin and confined together in a Fielde nest.[1] Although the two colonies took up their habitation in different parts of the same chamber, they were never seen to quarrel with each other. On one occasion some of the Cremastogasters even ventured to lick the red, saucer-shaped heads of the Cryptocerus soldiers!

III. CLEPTOBIOSIS.

Those ants which live in or near the nests of other species and prey on the larvæ or pupæ, or surreptitiously consume

[1] This artificial nest invented by Miss Adele M. Fielde ('00) is superior to any other that I have used. It requires closer attention than the Janet nest in order that the requisite amount of moisture may be maintained, but this slight disadvantage is outweighed by numerous advantages. The ventilation of the chambers is excellent, the closest inspection of the ants is possible, and the nests are easily handled, transported, and cleaned.

certain substances in the nests of their hosts, may be grouped together as clebtobiotic species. Owing to the present incompleteness of our knowledge, this category is not very clearly circumscribed, so that further researches may greatly extend its meaning or lead to its division into several categories.

All the known cleptobiotic ants are of minute size and of subterranean habits. They are pale colored and seem to have a predilection for living with rather large ants. The minute species of Solenopsis (*S. fugax* Latr., *orbula* Emery, *latro* Forel, *molesta* Say), and according to Forel ('94, pp. 23, 24) certain species of Monomorium (*M. andrei* Saunders), and the species of the oriental genera Oligomyrmex, Melissotarsus, Carebara, Tranopelta, and Aëromyrma, belong to this category. *Monomorium termitobium* Forel enters into cleptobiotic relations with termites in Madagascar. Forel notes the following significant facts concerning these different species: "It is more than probable that the extremely minute size and subterranean life of the worker of these species are the results of natural selection. The workers are very small, yellow, and blind, or nearly so, whereas the large females and males, of a brown or black color, with wings and large eyes, are witnesses to the fact that the minute size, etc., of the worker is due to an extraordinary regressive development. The female of *Carebara lignita* West. is 20 mm. long and 4–6 mm. in diameter, while its worker, which I owe to the kindness of M. Emery, is only 2 mm. long! It is obvious that the minute size of the worker is its safeguard. For owing to its minuteness it succeeds in insinuating itself into the young brood of large ants or termites without being seen by the defenders. It assassinates the young in their swaddling-clothes, incapable of defending themselves. As it lives very near its hosts, it requires neither size nor strength for seeking its food at a distance, and it is therefore in a position to nourish its enormous females and males with facility. Thus it is easy to see how this form of parasitism should lead to a diminution in the size of the worker, in depriving it of its eyes, and in giving it a pale color, while the females and males which mate in the air retain their size, visual organs, and coloration."

The only cleptobiotic ant which has been at all carefully studied is the European *Solenopsis fugax*, a species with minute yellow workers and black males and queens. We owe

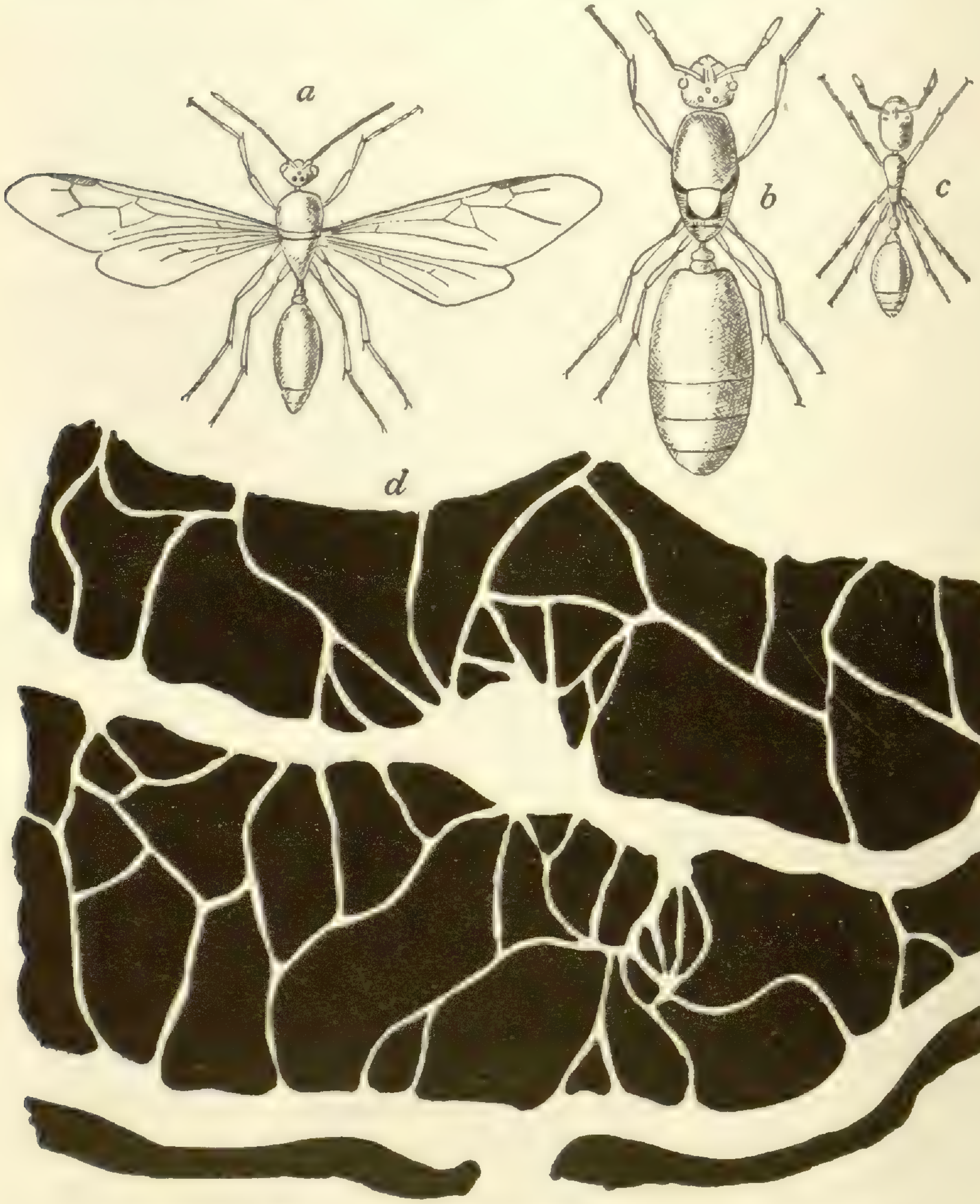

FIG. 10.—*Solenopsis fugax* Lat. (after Wasmann). *a*, male; *b*, deälated female; *c*, worker; *d*, portion of nest, showing tenuous galleries of Solenopsis entering the large galleries of the host-ant.

our knowledge of the behavior of this species to the labors of Forel ('**69**, '**74**), Wasmann ('**91**), and Janet ('**97**). I insert Wasmann's figure (slightly modified) of this insect and its nest, together with a translation of Janet's *résumé* ('**97**, pp. 58–60),

as both are of considerable interest in connection with our closely allied American species, *Solenopsis molesta*:

"The Solenopsis may establish itself near almost any other ants of our country. It is found especially with *Formica fusca*, *F. rufibarbis*, *Polyergus rufescens*, *F. rufa*, *F. pratensis*, *F. sanguinea*, *F. cinerea*, *Tetramorium cæspitum*, and *Myrmica scabrinodis*. Frequently it is possible to observe that the two nests are in close contact with each other. The Solenopsis nest may partially surround that of its neighbors, or it may even be excavated in part in the masses of the earth separating the galleries of the latter. That the two nests so near each other are not merely two contiguous nests, but deserve a special name such as the term 'double nest' employed by Forel, is proved by the fact that fine connecting galleries enable the Solenopsis to make incursions into the nests of their neighbors, where, as we shall see, they find an abundance of food. Wasmann ('**91**, p. 21) mentions an extremely populous nest provided with some twenty queens and extending in a semicircle around the subterranean portion of a *Formica pratensis* nest, with which it communicated by means of fine pillaging galleries. Forel and Wasmann, however, have also met with isolated nests.[1] At Beauvais I was able to ascertain, by following carefully during several hours the spading of a piece of land which was exposed to the south and had been left untouched for several years and was almost devoid of stones, that the nests of Solenopsis may often be isolated, or at least noticeably distant from the nests of any other species. Nevertheless, this distance does not at all exclude the possibility of a communication by means of long galleries with the ant nests of the neighborhood, *e.g.*, with those of the Tetramorium, which were not rare in the same piece of ground. It is probable that the Solenopsis, when necessary, manages to go a considerable distance in search of the ant pupæ that appear to constitute its principal food, but there is, nevertheless, a propensity to settle near the nests which furnish this food, and this approach is favored by the presence of stones, under which ants have such a pronounced tendency to shelter themselves. . . . In the sandy

[1] Emery ('**95**) also records the occurrence of such nests near Bologna, Italy.

soil of the piece of land above mentioned I obtained some fine and very clear vertical sections of the nests of the Solenopsis. They consisted of small chambers of a circular form measuring 8–20 mm. in diameter and only 6–8 mm. in height. Most of these chambers were at least several centimeters apart. Their floors were remarkably clean, smooth, and even hardened. They were connected by tenuous galleries, often less than 2 mm. in diameter, entering the chambers at their ceiling, at their lateral walls, or at their floors, and uniting with their surfaces by means of a perceptible infundibular orifice. Forel ('**74**, p. 385) saw several Solenopsis leave the earth and steal in among a stack of cocoons which had been heaped up by some *Formica pratensis* that had been dumped on the ground. The Solenopsis set to work perforating the cocoons and cutting the pupæ to pieces, thus destroying a great number of them. Forel is correct in his inference that the Solenopsis behave in the same manner in double nests. At this writing I repeat this observation daily on an artificial double nest of *S. fugax* and *F. rufibarbis*. Every day I give the Solenopsis about ten cocoons of Lasius queens, placing them near the entrance of the nest. It is not long before the Solenopsis make their appearance. From ten to thirty of them climb up onto each cocoon and cover it with little perforations, which, finally becoming confluent, enable them to reach its contents. If it contains a pupa, the legs and antennæ fall an easy prey to the mandibles of the Solenopsis. In this case the victim is cut into, sucked, and torn into very small pieces, which the ants hasten to carry away into the interior of the nest. The operation is much more difficult if the contents is a larva which has just spun its cocoon, or a pseudonymph. I have seen the Solenopsis drag a larva of this kind into the interior of the nest and keep working at it for twenty-four hours. At the expiration of this period the larva began to look flaccid and was covered with little black dots, which were sometimes double, corresponding with the little wounds made by the mandibles. Numbers of the Solenopsis were busy lapping up the liquid which exuded from the wounds, but it was not until thirty-six hours had elapsed that the larva was entirely devoured. Large

species of ants are unable to enter the nests of their neighbors, as the galleries of the latter are too narrow ; and when the two species happen to meet one is inclined to believe, with Forel ('**74**, p. 246), that the small size of the Solenopsis renders them invisible to the larger ants. Then, too, in case of a conflict, the Solenopsis are numerous enough and sufficiently well armed with stings to kill even *Formica sanguinea*. In my double artificial nests I often saw one of the latter killed by a group of five or six Solenopsis, but on such occasions I also found a considerable number of Solenopsis cadavers on the refuse-heaps."

II. **Solenopsis molesta** Say.

The European *S. fugax* is represented in North America by a very closely allied species, — *S. molesta* Say. (= *S. debilis* Mayr.), — a minute yellow ant with yellow queens and dark brown males. The species has a very wide geographical range. It has long been known from the Eastern and Northern States and appears to be equally common in Texas. Although not mentioned in Forel's monograph ('**99**), it extends through Mexico, where I have taken it as far south as Cuernavaca in Morelos. Emery has described a variety *validiuscula* from California.

The habits of *S. molesta*, so far as I have been able to observe them, are the same as those of *S. fugax*. Although like its European congener it sometimes occurs in isolated nests, and even in houses, it has, nevertheless, a decided predilection for forming compound nests, essentially like those of *S. fugax*, with larger ants. In the Northern States it often consorts with the different species of Formica, Lasius, Stenamma, and Myrmica. In Texas it is of almost regular occurrence in the large nests of *Pachycondyla harpax* and *Odontomachus clarus*, and often occurs with the different earth-inhabiting species of Camponotus (*C. fumidus*, var. *festinatus* Buckley ; *C. maculatus*, subsp. *sansabeanus*). In Mexico I have taken it with a variety of *Odontomachus clarus*. In one nest of *S. molesta*, discovered near Austin, I found the workers feeding on a dead cricket lying in the galleries of *Pachycondyla harpax*. As

S. molesta sometimes occurs far from the nests of other species, it would seem that it must often feed on other substances than the larvæ and pupæ of ants. Under these circumstances its diet may be similar to that of the European species which Emery ('95, p. 277, footnote) found near Bologna feeding on the bones and dead bodies of small animals.

12. **Pheidole lamia** n.sp. (Fig. 11 *a–c*).

This aberrant Pheidole, which I have recently taken near Austin, Texas, is, I believe, to be included among the cleptobiotic ants. It is, unfortunately, of very rare occurrence, so that up to the present time I have found only two of the nests — both under stones in rather moist, shady places. One of these nests contained a small number of workers which were feeding on a partially decomposed caterpillar. The other, containing a greater number of workers (about twenty-five), was on a refuse heap consisting of several dead ants, in the midst of a nest of *Camponotus maculatus*, subsp. *sansabeanus*. The honey-yellow workers were only 1.5 mm. long, and to the unaided eye so closely resembled the very common workers of *Solenopsis molesta* as to convince me that I must

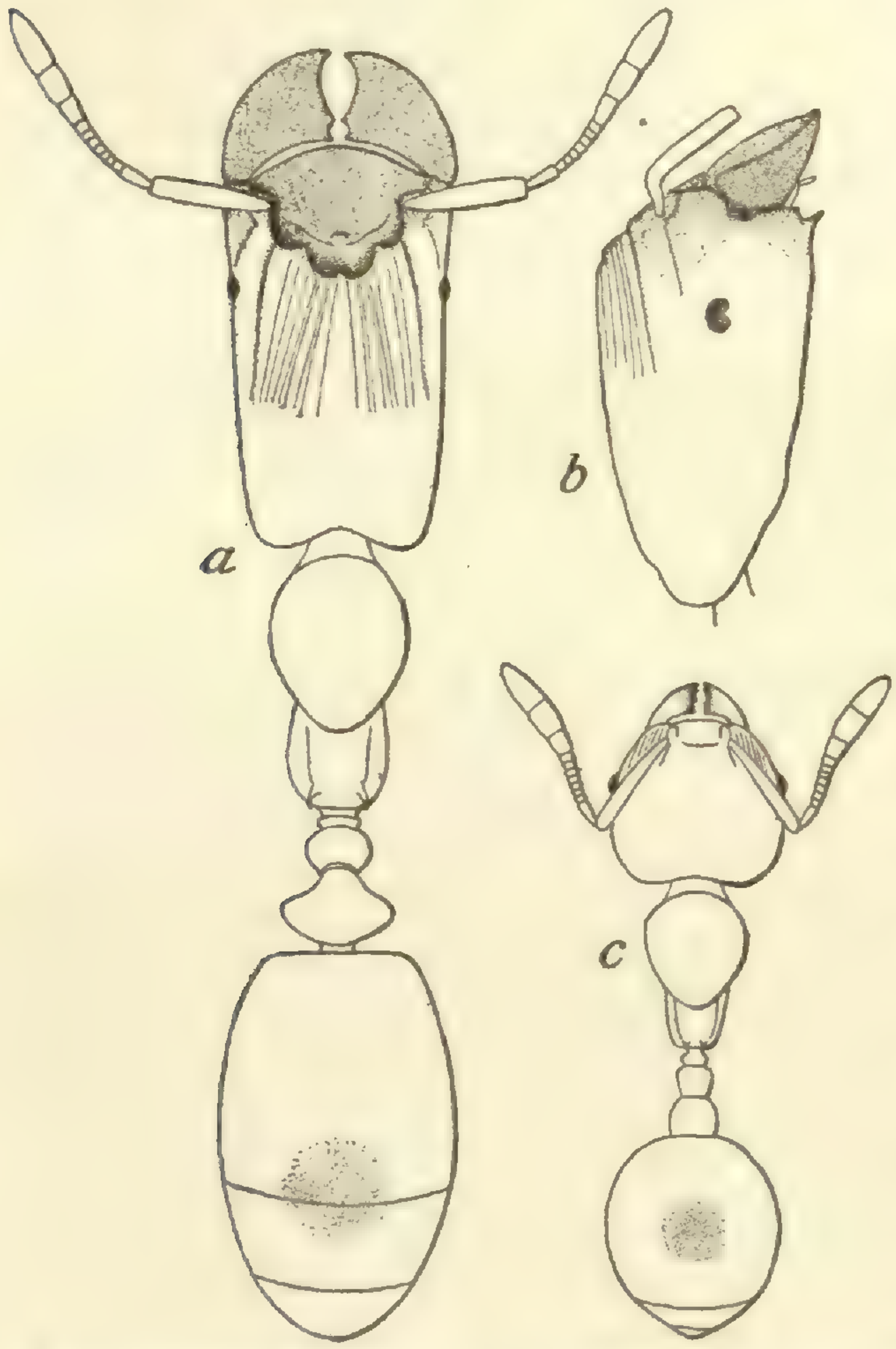

FIG. 11. — *Pheidole lamia* n.sp. *a*, soldier; *b*, head of same in profile; *c*, worker.

have overlooked these ants on several former occasions. They had evidently been feeding on the dead Camponotus and were moving in and out of their tenuous galleries excavated below the refuse heap in the compact black soil. On digging I discovered the singular soldier (2.5 mm. long, Fig. 11 *a*), which is unlike the soldier of any other Pheidole known to me except *Ph. absurda* Forel from tropical America. Forel's species, however, is larger and exhibits several other differences. The soldier of *Ph. lamia* is smooth and of the same honey-yellow color as the worker, except for the rough, brownish, Colobopsis-like anterior portion of its head. The abdomen of both soldier and worker has in its center a large dark spot, which is produced by the black contents of the stomach seen through the thin integument. The visual organs in both castes have undergone the usual reduction noticeable in hypogæic ants — there being scarcely more than a dozen facets in each of the small, emarginate eyes of the soldier.[1]

IV. Xenobiosis.

The inquilines, or guest ants (*Gastameisen*), constitute a group of considerable interest, since it is not improbable that these insects may ultimately give us some clue to the conditions that have led to the development of mixed nests from those of the double or compound variety. Unfortunately we know very little of the habits of some of the species that have been recorded as guest ants. So far as known the inquilines maintain their independent households, although they consort freely with their hosts and live with them on terms of mutual toleration, or even friendship. The best-known guest ant is the

[1] It is probable that several of our North-American species of Strumigenys are cleptobiotic. In a former paper ('00 *a*, p. 31) I recorded the occurrence of *S. louisianæ* in the nest of *Pachycondyla harpax*. While this paper is going to the press Rev. P. J. Schmitt writes me that "*S. pergandei* Emery, more than any other species of this genus, is almost always, at all events more frequently than not, to be taken in the nests of *Formica subsericea*, *F. exsectoides* or the slaveholders *F. rubicunda* and *subintegra* in the ground, and with *Lasius aphidicola* in rotten wood. There — after the fashion of *Solenopsis molesta* — it occupies a small chamber of its own, which connects with the galleries of the larger ants. These peacefully tolerate and scarcely notice their tiny neighbors."

European *Formicoxenus nitidulus*, which has been carefully studied by Adlerz ('**84**), Forel ('**74**, '**86**), Wasmann ('**91**), and Janet ('**97**). It is a singular fact that, notwithstanding all these valuable observations, the feeding habits of the Formicoxenus have never been observed. As this ant, in certain particulars, strikingly resembles *Leptothorax emersoni*, Janet's *résumé* ('**97**, pp. 54–56) of what is known concerning its behavior may be quoted before recording the little that is known concerning our American guest ants.

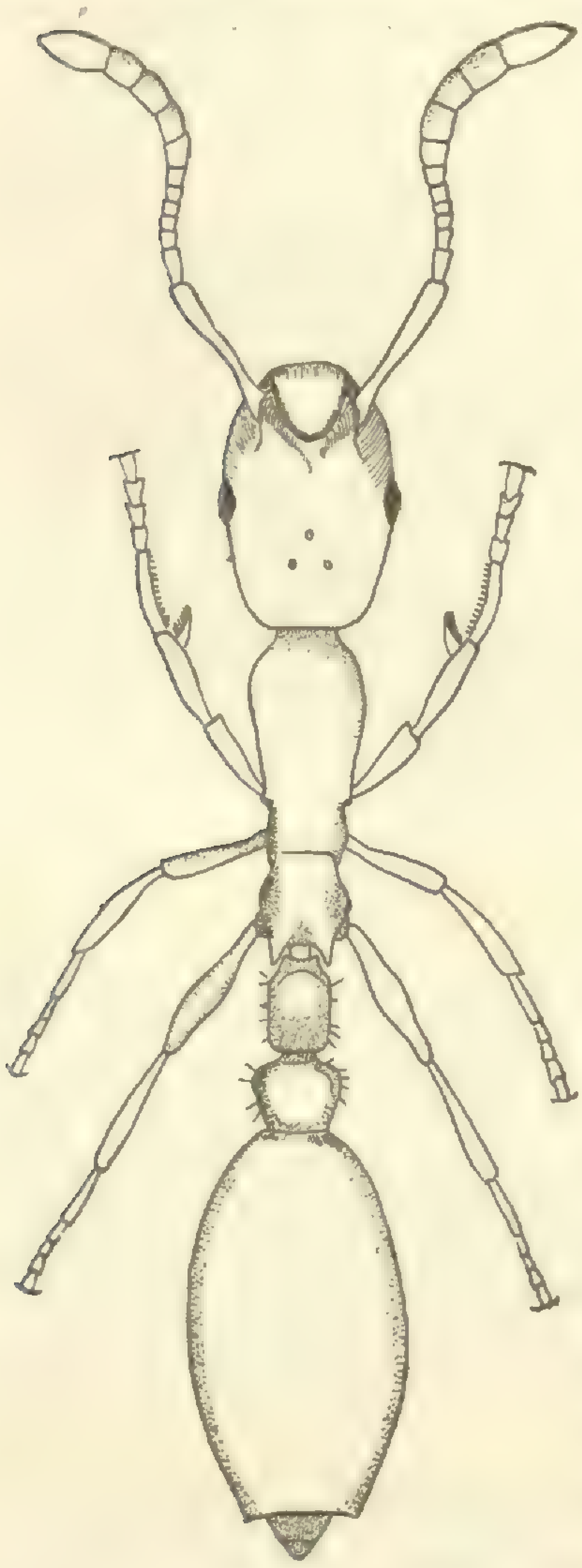

FIG. 12.— *Formicoxenus nitidulus* Nyl. Male (after Adlerz).

"*Formicoxenus nitidulus* is a pretty little species of very timid character. Forel found it to be a rare insect in Switzerland. I have several times taken small colonies of it at Beauvais. Wasmann mentions it as very common in Holland. Adlerz found it abundant in southern Sweden. It is, therefore, a north European species. The worker scarcely reaches a length of 3 mm., and the queen is but little larger. The male (Fig. 12), discovered by Adlerz ('**84**), is apterous like that of *Anergates atratulus* and like one of the male forms of *Ponera punctatissima*. Its shape, color, and the absence of wings make it difficult to distinguish from the worker. It may, nevertheless, be recognized from other external male characters. Its antennæ are more strongly recurved at their tips and are 12-jointed; *i.e.*, they have one more joint than the female phases (either queen or worker). In the abdomen five segments (the 7th to 11th) are visible from the exterior instead of four (segments 7 to 10) as in the females. The mandibles are smaller; the ocelli are well developed. The relations of *Formicoxenus nitidulus* to its host have been especially studied

by Adlerz ('84). Its colonies, usually consisting of a small number of individuals, may, however, be very populous at times. It establishes its nest in the very interior of the nest of *Formica rufa* or of *F. pratensis*. The small chambers which it there constructs and inhabits, together with its progeny, communicate by means of large openings with the galleries of the Formica nest. Wasmann ('91, p. 35) found a colony of Formicoxenus consisting of workers, males, queens, and young, inhabiting the cavity of an old cocoon of *Cetonia floricola*, a beetle which lives during its larval stages in the bottom of the nest of *Formica rufa*. *Formicoxenus nitidulus* often moves about among its hosts. The observations of Adlerz, Forel, Wasmann, and myself prove that these myrmecophiles are never met with outside of the nests of the *Formica rufa* and *F. pratensis*. They live in peace with their hosts, but they are not cared for by them, nor do they render them any service. Observers who have studied the behavior of this species have on exceptional occasions observed acts of a slightly hostile nature on the part of the two species, but these acts were without serious consequences. On one occasion, in one of my artificial nests, in which the ants had previously lived on good terms with one another, I saw a Formica touching a Formicoxenus with her antennæ and menacing her with her mandibles; but she departed without even attempting to seize the inquiline. In the same nest I found a Formicoxenus which had seized the leg of a Formica in its mandibles and had died in this position. The Formicoxenus (Forel, '86, p. 134) are able, either by themselves or by carrying one another, to follow the files of their hosts when the latter move into a new nest. They also carry their progeny to the new nest. In the nests of their hosts they find shelter, warmth, and efficient protection from other ants, against which they would be unable to defend themselves. There they also find sustenance, but it has been impossible up to the present time to determine its nature."[1]

[1] In Emery's *Beiträge* ('95, pp. 271, 272), *F. nitidulus* is cited as occurring in North America. The specimens to which Emery refers were labeled "Rocky Mountains." But Emery (*in litteris*) has expressed grave doubts concerning the

13. **Xenomyrmex stollii** Forel (Fig. 13).

X. stollii is a small, smooth, dark brown ant, allied to the species of Monomorium. It is a native of Guatemala and was found, together with its larvæ and pupæ, living in a huge oak gall in company with a much larger ant, *Camponotus abscisus* Rog. More recently a subspecies, *floridanus*, of this same species was discovered at Lake Worth, Fla., by Mr. Pergande. (See Emery, '95, pp. 275, 276.) On this occasion the ants were living, unaccompanied by another species, in a hollow twig of *Xyderoxylon masticodendron*. Wasmann ('94, p. 163) expresses some doubt as to whether the Guatemala form really forms a mixed colony with the Camponotus, since the ants are members of different subfamilies; but he nevertheless regards this case as in a sense transitional to the mixed nest, since Xenomyrmex appears to build no nest of its own. From an inspection of our Texan oak galls, which are frequently inhabited by ants, I feel sure that nests of very small size on the plan

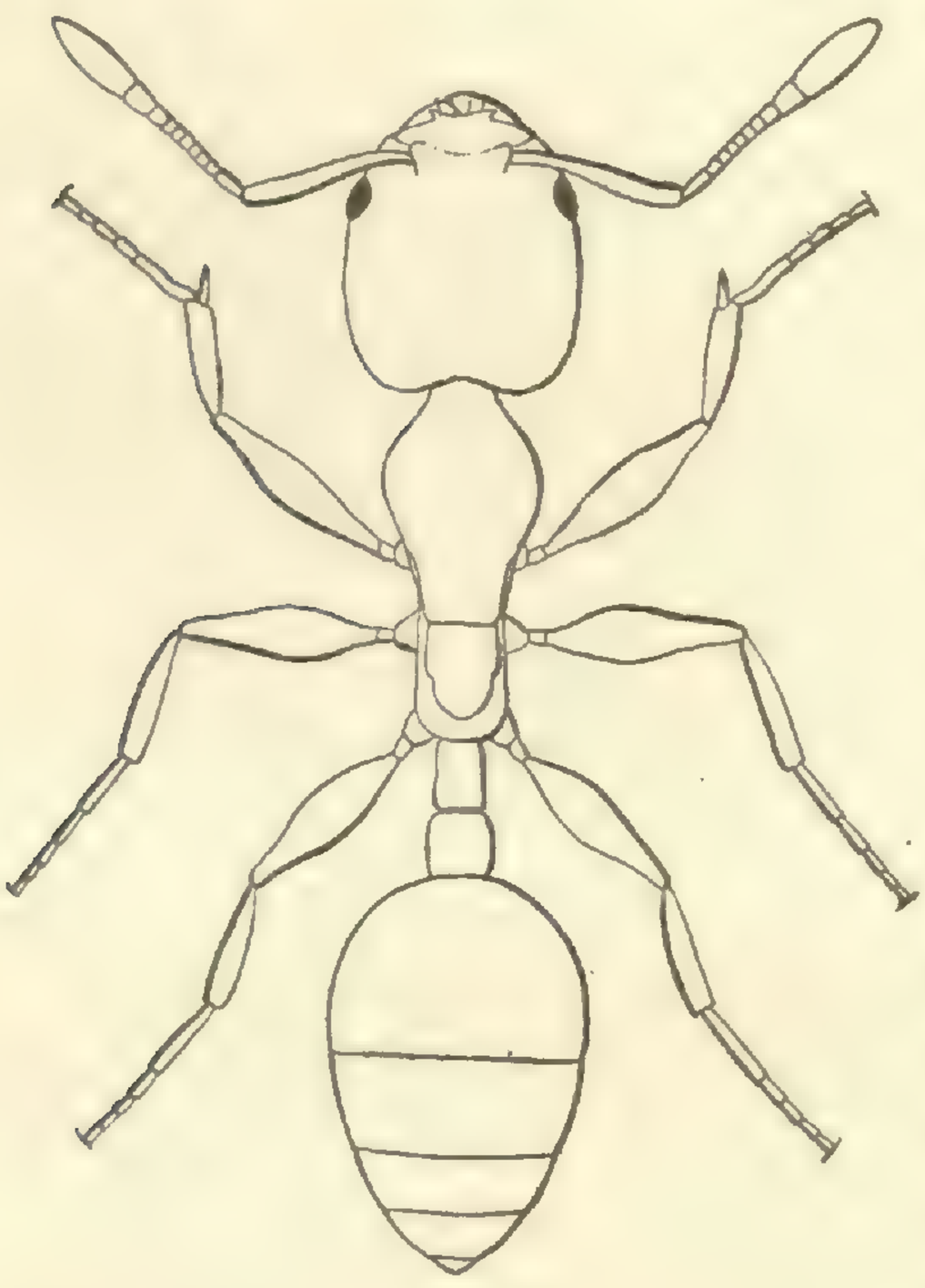

FIG. 13. — *Xenomyrmex stollii* Forel. Worker.

occurrence of Formicoxenus in this country. My own reference to this form as occurring at Colebrook, Conn. ('00, p. 48, footnote), is based on a wrong identification. The species there recorded is really *Leptothorax emersoni*, which in size, color, and superficial appearance resembles *Formicoxenus nitidulus*.

Two additional species of Formicoxenus have been recently discovered in Europe, and both have been described from female specimens only. *F. ravouxi* André ('96) was captured in a normal nest of *Leptothorax tuberum* Fabr., subsp. *unifasciatus* Latr., provided with fertile queens. The host of the other species, *F. corsicus*, described by Emery ('95 *a*, p. 12), is unknown.

Emery also describes (*ibid.*, p. 11) another ant, *Phacota noualhieri*, from a single specimen taken in a nest of *Monomorium salomonis*, var. *subnitidum*. Emery regards the new species as being in all probability parasitic or inquiline in its habits.

of the double nests of the *Formica rufa* and Formicoxenus could be formed even within one of these circumscribed vegetable growths. The guest ant could inhabit the central capsule (in which the gall fly passes its pupal stage), while the host ant might occupy the chambers dug in the ligneous substance of the gall. I am led to this supposition by finding that a new species of Leptothorax, which regularly nests in the *Holcaspis cinerosus* galls formed on the live oaks about Austin, prefers the small central capsule as a nursery. Here the single queen lives wedged in between the eggs, larvæ, pupæ, and a few workers, while the chambers of the gall are commonly tenanted by the bulk of the workers.

FIG. 14.—*Leptothorax* (*Dichothorax*) *pergandei* Emery (after Emery). *a*, antenna of same.

14. **Leptothorax** (**Dichothorax**) **pergandei** Emery (Fig. 14).

Our knowledge of this species, too, is extremely meager. It was described by Emery ('**95**, pp. 323, 324) from specimens taken as guests in a nest of *Monomorium minutum*, var. *minimum*, at Washington, D. C., by Mr. Pergande.

15. **Leptothorax emersoni** n.sp.

The Leptothorax described in detail in the first part of this paper may be included among the guest ants, although it certainly resembles in many respects the cases of dulosis and social parasitism.

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(To be continued.)

ON THE OSTEOLOGY AND SYSTEMATIC POSITION OF THE ALCÆ.

DR. R. W. SHUFELDT.

Some twelve or thirteen years ago I published several illustrated papers upon the osteology of the Alcæ, they having appeared in the *Journal of Anatomy* of London (Vol. XXIII, N.S.; Vol. III, October, 1888, pp. 1–39, Pls. I–V; January, 1889, pp. 165–186, Pls. VII–XI; April, 1889, pp. 400–427, Figs. 1–17 (text); July, 1889, pp. 537, 538, Figs. 1–8, and October, 1889, pp. 89–106, Pls. VI–VIII). In the text-figures and plates to these memoirs will be found reproductions of drawings of mine of the bones of a great many species of Alcæ, as *Alca torda*, *Plautus impennis*, Uria (two species), Synthliborhamphus, Cepphus, Brachyrhamphus, Lunda, Fratercula, Cyclorrhynchus, Simorhynchus, and others. In some cases several species of each are illustrated, there being upwards of one hundred figures in all. The descriptions are quite in detail, and taken in connection with the cuts and plates present accounts of nearly all the auks and puffins and their immediate allies known to science the world over. In fact, the only genera not thus treated are Pseuduria, Micruria, and Ceratorhyncha, and it is not likely that the osteology of any of these differs very much from that of known forms more or less nearly related to them, and certainly not to an extent to modify the present views of avian taxonomers upon the classification of the Alcæ. It will not, therefore, be necessary to reproduce much, if any, of that work in the present connection, and so far as the osteology of the extinct great auk (*Plautus impennis*) is concerned it has been very thoroughly described by numerous writers, and particularly by Sir Richard Owen and Mr. F. A. Lucas of the United States National Museum. To illustrate the present paper, however, I will offer a figure of the skeleton of the great auk, in order not

only to complete my series of illustrations of the skeletons of these birds, but also to bring before the readers of this paper the skeleton of a typical auk as a convenient reminder of the osteological characters of the bird forms here being considered. My space, therefore, will be principally occupied by a presentation of the various views of avian systematists on the position of the Alcæ in the system.

The auks and puffins, as is well known, constitute a very well circumscribed and distinct group of birds, with apparently no outlying forms, and, apart from *Plautus impennis*, no fossil remains of any species of them have as yet been discovered, or at least described. Dr. Sharpe records none in his *Hand-List of Birds* (1899, pp. 130–133).[1] Notwithstanding these facts, the opinions of the classifiers of birds are by no means unanimous on the question of the systematic position of the Alcæ. Professor Huxley, for example, grouped the Laridæ and the Alcidæ in one of his suborders, — the Cecomorphæ, — and said of the last-named family, "The Alcidæ in their pterylosis and other characters approach the penguins, especially through *Alca impennis*" (*Proc. Zoöl. Soc.*, 1867, p. 458); and Newton has remarked that "the affinity of the Alcidæ or auks (and through them the divers or Colymbidæ) to the gulls may be a matter beyond doubt, and there appears to be ground for considering them to be the degraded offspring of the former; but to the present writer it appears questionable whether the grebes (Podicipedidæ) have any real affinity to the two families with which they are usually associated; and this is a point deserving of more attention on the part of morphologists than it has hitherto received" (*Encycl. Brit.*, 9th ed., Vol. XVIII, art. "Ornithology," p. 45). Garrod, later on, who certainly entertained very peculiar notions about

[1] As this article goes to press I would say that a part of a fossil bone of an auk has been received by Mr. Lucas of the United States National Museum from a party in California, where it was found. This specimen I have been permitted to personally examine. It consists of the proximal moiety of a humerus that belonged to a species apparently as large as Plautus, but exhibiting even a more feeble development of the pectoral limbs. Mr. Lucas has described this specimen before the Biological Society of Washington, D.C., and his description will be published later on.

the affinities of birds, arrayed his Order IV, the Charadriiformes, between his Ciconiiformes (Order III) and his subclass Anomalogonatæ (Order I, Piciformes). The Charadriiformes were made to contain two cohorts (*a* and *β*), namely, the Columbæ and the Limicolæ, the latter being represented by the Charadriidæ, the Gruidæ, the Laridæ, and the Alcidæ. When one considers the birds he grouped in his Ciconiiformes and his Piciformes, such a classification is surely to be regarded more in the light of a taxonomical curiosity than to be taken seriously as a contribution to the *natural* classification of birds (cf. *Proc. Zoöl. Soc.*, 1874, p. 116).

As to the view entertained by Mr. W. A. Forbes on the position of the Alcæ, I have a number of letters from him on the subject, written to me from London, just before he left on his fatal trip to Africa, in which this question is referred to and set forth. These will be published in another connection by the present writer, together with others on various scientific matters of interest. Forbes's classification of birds was written out by him in his diary only four days before his death on the Niger, but it is more or less fragmentary, and I shall not discuss it here (cf. *Ibis*, 1884, p. 119).

Dr. P. L. Sclater, in his classification of birds, places the two families Colymbidæ and Alcidæ as alone constituting the group Pygopodes (Order XXI), inserting them in his scheme between the Tubinares and Impennes (Orders XX and XXII, respectively). (See *The Ibis* for 1880.) This is certainly at variance with Professor Huxley's views, though, as Dr. Sclater's Order XIX (Gaviæ) includes only the Laridæ, it agrees in one way with what Professor Huxley proposed, and that is, that the Laridæ, the Procellaridæ, the Colymbidæ, and the Alcidæ, grouped as families, were next nearest the penguins in their affinities.

Dr. Reichenow (1882) surely did not appreciate the value of the osteological characters of the Impennes (penguins) when in his scheme of classification for Aves (*Die Vögel der Zoologischen Gärten*) he placed the Spheniscidæ, the Alcidæ, and the Colymbidæ as the three families constituting his second order, the Urinatores. Such an arrangement distinctly differs

from that of Huxley and others, and cannot be sustained upon morphological grounds, which are the only true ones to be considered in the natural classification of animals of any kind. Coues and Ridgway, as representative authorities of the American Ornithologists' Union (1884–95), consider the Alcidæ to be a family of the order Pygopodes, arrayed with the Urinatoridæ in a suborder, Cepphi. Why a grebe (Æchmophorus) and a puffin (Lunda) should, as birds, be associated in the same order, is quite beyond the comprehension of the present writer, who believes that Professor Cope went equally wide of the mark when, in his classificatory scheme for Aves, he made an order, Euornithes, which is included in his superorder Eurhipiduræ ; and in the former, the Alcidæ fall within the suborder Cecomorphæ (cf. *Amer. Nat.*, October, 1889).

The late Professor William Kitchen Parker, in his admirable memoir *On the Morphology of the Duck and Auk Tribes*, says, on page 91: "I am under the impression that penguins never possessed quills, and that their adaptation to aquatic life and their great power of diving took place much earlier in their ancestral history than in the case of the auks and guillemots — birds that tend to become a sort of palearctic penguin but never quite lose the marks of their former adaptations to a more terrestrial life. I conceive of their ancestors in amphibious or limicolous birds, and I imagine the forefathers of gulls, plovers, rails — the auk tribe — as being very much alike and very nearly related. . . . All the penguins are alike in everything that is important; of the Alcidæ only one, *Alca impennis*, became transformed into the likeness of a penguin; the specialization of the family has been imperfect as compared with the penguins, and, as I believe, took place later in time" (*Cunningham Memoirs*, No. VI, Royal Irish Academy, Dublin, November, 1890).

A marked approach toward a natural classification of the several groups of birds I have been considering here was arrived at when Dr. Leonard Stejneger published his scheme in 1885 (*Standard Natural History*, Boston). In it the

arrangement proposed by this keen observer of morphological characters in animals is, in the case of the birds in question, as follows:

Superorder	Order	Superfamily	Family
(II) Impennes	(V) Ptilopteri		Spheniscidæ
(III) Euornithes	(VI) Cecomorphæ	Colymboideæ	Colymbidæ
		Heliornithoideæ	*Heliornis* (Heliornidæ)
		Alcoideæ	Urinatoridæ, Alcidæ
		Laroideæ	Stercorariidæ, Laridæ
		Procellaroideæ	Diomedidæ, Procellaridæ, Pelecanoididæ

From this it will be seen that the penguins (Spheniscidæ) are well separated from the grebes (Podicipedidæ: *auct.*) and these latter from the loons and auks, an arrangement which is a very natural one, based as it is upon an appreciation of the structural characters of the representatives of the families considered. Still, in the opinion of the present writer the association of the Urinatoridæ and the Alcidæ is too close, and not warranted upon morphological grounds.

Several years later, Dr. Hans Gadow (*Proc. Zoöl. Soc.*, 1892, p. 229) also proposed a "Classification of Birds," in which he attempted to employ all the known structural characters of the class Aves, as well as the previous opinions of all recognized authorities upon avian taxonomy. His position selected for the Alcæ is shown in the following scheme, abstracted from his arrangement as a whole:

16. Charadriiformes	I. Limicolæ	Chionididæ, Charadriidæ, Glareolidæ, Thinocoridæ, Œdicnemidæ, Parridæ	
	II. Gaviæ	Alcidæ, Laridæ	

In this scheme Dr. Gadow includes Attagis in the Thinocoridæ, and very widely separates the Charadriiformes, as constituted above by him, from the Sphenisciformes (8 of his scheme) and the Procellariiformes (9 of his scheme), — these last two groups having the Ardeiformes (10), the Falconiformes (11), the Anseriformes (12), Crypturiformes (13), Galliformes (14), and Gruiformes (15), standing between the Colymbiformes (7) and the aforesaid Charadriiformes (16). In other words, the loons and grebes are separated in this lineal arrangement from the group containing the auks and gulls, by the groups containing the penguins, the Tubinares, the Steganopodes, the herons, the Cathartidæ and Accipitres, the Crypturi, the fowls, and the Gruiformes.

This curious arrangement has doubtless been produced by the way in which the structural characters have been employed and contrasted. The entire scheme is highly unnatural in many particulars, as, for example, the relations indicated for the flamingoes to the storks, the two families alone representing the Pelargi, and this last group being associated with the herons and Steganopodes in an order, Ardeiformes. Between this last and the order Anseriformes stands the order Falconiformes, thus giving not the slightest suggestion as to the undoubted relation of the flamingoes to the anserine birds. This comes of the danger of using too many structural characters, and those characters of very different values and weight, and not properly contrasted. Such a practice will be sure to lead one away from the correct solution of the true relationships existing among birds in nature, taking the group as a whole, both existing and extinct, since birds were birds at all, in time; — and it is the expression of this in a taxonomic scheme of some sort or other that really we all are so desirous of perfecting. Sometimes, too, even the *lineal* scheme of so high an authority as Dr. Max Fürbringer is open to the same criticism, but not so when we come to examine the famous "avian tree" he constructed for us, and published in his great classic on the subject, *Untersuchungen zur Morphologie und Systematik der Vögel*, in 1888. With respect to the Alcæ, in

his lineal arrangement Professor Fürbringer classifies the family Alcidæ as follows:

Charadriornithes (*Ægialornithes*)	Charadriiformes	Laro-Limicolæ	Charadrii	Charadriidæ
				Glareolidæ
				Dromadidæ
				Chionididæ
				Laridæ
				Alcidæ
				Thinocoridæ
		Parræ		Parridæ
		Otides		Œdicnemidæ
				Otididæ

The relationships are exhibited more naturally in his "Phylogenetic Tree," where the offshooting of the various groups and subgroups can be much better appreciated, as they are, too, in the several sectional projections of the "Tree" he has given us.

Finally, passing over the several attempts of the late Mr. Henry Seebohm to classify the class *Aves* in so far as orders and suborders are concerned, and the earlier provisional schemes of Dr. R. Bowdler Sharpe, I come to the last one of the latter eminent authority as set forth in his *Hand-List of Birds*, published by the British Museum in 1899 (Vol. I, p. 130).

In this scheme the following arrangement has been proposed:

Orders	Families	Subfamilies
XII. Procellariiformes	Procellariidæ	Procellarinæ
		Oceanitinæ
	Puffinidæ	Puffininæ
		Fulmarinæ
	Pelecanoididæ	
	Diomedeidæ	
	Incertæ Sedis . .	(Hydrornis)
XIII. Alciformes . .	Alcidæ	Alcinæ
		Fraterculinæ
XIV. Lariformes . .	Laridæ	Sterninæ
		Rhynchopinæ
		Larinæ
	Stercorariidæ	
	Incertæ Sedis	(Halcyornis)

There is a great deal to be said in favor of this classification, and it can be largely supported when the osteological characters presented on the part of the bird forms representing these various families are taken into consideration, as I have already demonstrated in my memoirs in the *Journal of Anatomy and Physiology* of London cited in a former paragraph of this paper. Dr. Sharpe is also quite correct when he places, as he does, in *The Hand-List of Birds* these three orders between the Charadriiformes upon the one hand and the Sphenisciformes upon the other.

Synopsis of the Osteological Characters of the Alcæ.

1. The superior mandible of the skull varies in its morphology. It may have its anterior portion elevated, convex, prominent, laterally compressed, and cultrate, terminating in a sharp hook, as in Alca, Fratercula, and Lunda; or, the superior mandible may not be hooked, the foregoing characters remaining the same, as in Cyclorrhynchus; or, it may taper gradually to a point, with the culmen roundly convex and not modified, as in Synthliborhamphus, Brachyrhamphus, Cepphus, and in Uria; or, finally, it may be broad at its base, and shortened, while its general characters remain the same.

2. With regard to the *supraorbital glandular depressions*, they may be entire, the upper orbital rim being finished off with an osseous emargination; and this associated with the *crotaphyte fossæ* either reaching the supraoccipital prominence or encroaching upon its summit, as in Alca and in Uria; or, the supraorbital glandular depressions may not be entire, the upper orbital rim being absorbed, producing wing-like postfrontals, and these characters associated with lateral crotaphyte fossæ, as in Fratercula, Lunda, Simorhynchus, Ptychorhamphus, Synthliborhamphus, Brachyrhamphus, and Cepphus. (It is in Brachyrhamphus that the crotaphyte fossæ are lateral.)

3. The extent to which the *interorbital septum* and the anterior wall of the brain-case ossifies varies greatly with age and is therefore an unreliable character. There is always more or less bony deficiency in these parts in the Alcæ.

In *Cyclorrhynchus psittaculus* the maxillo-palatines are nearly horizontal, while in Lunda they are nearly vertical, the angle for these bones varying between these two planes for the different genera, they having an obliquity of about 45° in Alca and Uria. The *vomer* also varies; in Alca and Uria it is never produced as a spine in front, while this is its normal condition in Simorhynchus and the Auklets generally. In certain Fraterculinæ it varies between these two extremes.

4. The *mandible*, though varying not a little throughout the group, presents in its general form the same fundamental characters in all. The angle is always recurved, the surangular is pierced by one large foramen, or two small ones; the ramal vacuity is usually closed by the splenial or dentary, and the sides of each ramus are more or less vertical, and the symphysis comparatively short. It is V-shaped when viewed from above.

5. As a rule, the Alcæ have the first pair of small free ribs on the fourteenth vertebra, followed by a better developed free pair on the fifteenth. In Brachyrhamphus and Synthiloborhamphus, the first pair of free riblets may be found on the thirteenth vertebra. Again, the number of ribs reaching the sternum through costal ribs varies, the variance depending upon a greater number of posterior pairs in some of the species. As we pass from the typical auks to the puffins the number of pairs of ribs decrease; for instance, *Alca torda* has *nine* pairs posterior to the first two free pairs, eight of which articulate with costal ribs, and they become long and sweeping behind. *Lunda cirrhata*, as a rule, has but *seven* corresponding pairs, and only six of these articulate with costal ribs; and they are comparatively shorter and less sweeping.

6. The *pelvis* offers us no definite characters that can be relied upon as constant, beyond the gradual change in its form. It is long and narrow in Plautus, Alca, and Uria, to become shorter and more spreading posteriorly as we pass to other genera.

7. The number of free *caudal vertebræ* range from seven to ten, not including the pygostyle. I have found the latter number in a specimen of *Lunda cirrhata*.

8. When the xiphoidal extremity of the *sternum* is notched, it is 1-notched upon either side, but this is a very variable

character among the Alcæ. In some sterna a *small foramen may occur upon one side only*, and even this may be absent. Between these extremes a great variety of patterns is to be met with, as a notch upon one side and a foramen on the other, or both foramen and notch upon either side. The sternal body is long and narrow in Alca, Uria, Synthliborhamphus, Brachyrhamphus, and in the extinct Plautus — those species, on the other hand, in which the sternum has a single notch on either side, and a single foramen within its inner border, the sternal body is rather broader anteriorly and more spreading behind, as in Cepphus, Lunda, and Fratercula. In Simorhynchus the sternum, having the same fundamental pattern, is long and narrow, with the xiphoidal extremity much produced beyond the carinal termination, being swelled and concave above and with one large, oblique, elliptical *foramen* on either side. This character also varies for different genera and species. The skeletons of the limbs do not appear to offer any constant characters. Full descriptions of the morphology of these parts, as well as the various forms of the sternum, are given in my previous memoirs, and they are illustrated by numerous cuts and figures, both in the text and on the plates.

On the Systematic Position of the Alcæ.

The Alcæ constitute a suborder of birds, in which is included but the single family Alcidæ. This family may be conveniently divided into two subfamilies, — the Alcinæ, containing all the true auks, and the Fraterculinæ, containing the puffins. As a group the Alcæ are connected upon the one hand with the Limicolæ through the Longipennes ; in other words, to the great snipe-plover group, and their allies through the gulls and their allies. On the other hand, they are connected with the Pygopodes and Impennes through the Tubinares, that is, through the petrel types with the penguins, the loons, the grebes, and their extinct allies, the toothed birds of the hesperornithine type of structure. Later on these relationships will be set forth in my scheme of classification of the class *Aves*, now in the course of completion.

EXPLANATION OF THE PLATE.

Skeleton of the Great Auk (*Plautus impennis*). Reduced. *Coll. U. S. National Museum*, No. 18,117. This skeleton is made up of the bones of numerous individuals.

CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE UNDER THE DIRECTION OF E. L. MARK. No. 124.

SOME METHODS FOR USE IN THE STUDY OF INFUSORIA.

A. W. PETERS.

The Yarn Siphon.

In accurate experimental work with Protozoa it often becomes desirable to separate them from the culture water in which they have grown and also from the solid débris, zoögloea, etc., contained in it. For one or several organisms this may be done by means of the "wash drop," as recommended by Eyferth (*Einfachste Lebensformen*, Braunschweig, 1900).

To obtain clean specimens in larger numbers, the following method has proved efficient for many kinds of Infusoria. From the culture jar a quantity of liquid containing the organisms and the débris naturally occurring there is removed with a pipette to a Stender dish. In this the organisms are well distributed by sucking up the liquid into, and forcing it out of, the pipette a few times. This is occasionally repeated during the subsequent procedure. A few pieces of woolen yarn about 10 cm. long are then laid parallel in a single strand, held in water, and pressed together (not twisted) until thoroughly wet. This yarn siphon is then placed with one end in the Stender dish, now elevated, the other end hanging down on the outside, a receiving vessel being placed underneath. Soon ciliated organisms pass over the siphon and are received into the lower vessel. The yarn acts as a filter as well as a siphon, keeping back solid matter and likewise dead organisms. From time to time fresh water is added to the Stender dish to replace that lost by siphoning. The process thus far yields the Infusoria in a large quantity of diluted culture water.

THE TUBE FILTER.

Numerous tests of the usual process of downward filtration with ordinary funnel and filter have shown that Infusoria (Paramœcia) can be removed from the inside of the filter only with the loss of a large proportion of their number, unless the filter be repeatedly rinsed. This results in a dilution, sometimes undesirable, and is at best an uncertain way of preventing the loss of organisms. To obviate these difficulties, I have employed another method.

To concentrate the organisms into a small amount of water, to remove the culture fluid entirely if desired, and to change the medium at will, I have devised the following apparatus, which may be called a "tube filter." One end of a short piece of wide glass tubing is closed by a piece of filter paper held in position by means of a rubber band binding it to the outer circumference of the tube. The process depends essentially upon the quality and area of the filter paper employed. For rapid work with a quantity of about 50 cc. contained in a Stender dish I have used a tube approximately 3 cm. in diameter and 6 cm. in length. This tube is held in a vertical position by a clamp fastened upon a ring stand. Under the tube, upon an elevated support, is placed the Stender dish, or preferably a deeper vessel, with the organisms. The tube is lowered until its paper diaphragm comes within a few millimeters of the bottom of the Stender dish. In the tube is hung a filled glass siphon with the lower end of its outer arm bent upward to prevent its running empty. As the water rises through the filter paper and into the tube it is removed by the siphon. More culture water with organisms, or any other fluid desired as medium, is then added to that in the Stender dish. The addition of the former effects concentration, as does also the final withdrawal of most of the liquid. This process of upward filtration leaves nearly all the organisms in the Stender dish when the tube is removed. By means of a supplying bottle, described below, carrying an air tube and a siphon, water may be added to the Stender dish as fast as it is withdrawn by the tube filter. This secures continuous renewal of the medium with practically no current.

The U-Cell for Renewable Media.

Another device, which I shall call the U-cell, serves much the same purpose as the tube filter, but on a smaller scale. It has the advantage of facilitating microscopic observation and of permitting more rapid change of medium.

To make this U-cell (Fig. 1) there are necessary two slides (best thin), a few rubber bands, and darning cotton of large diameter and close fibre. A piece one and a half times the length of the slides used is held at one end with the forceps and dipped into water until thoroughly wet, care being taken not to loosen its fibres or to make its diameter uneven by rough handling, although after dipping it may be drawn lightly between thumb and fingers to insure complete wetting. This is then laid lengthwise upon one slide (which is best placed across the top of an open Stender dish) in the form of a long U, and the other slide laid upon it. The ends of the U barely project beyond the parallel ends of the slides at the open end of the cell.

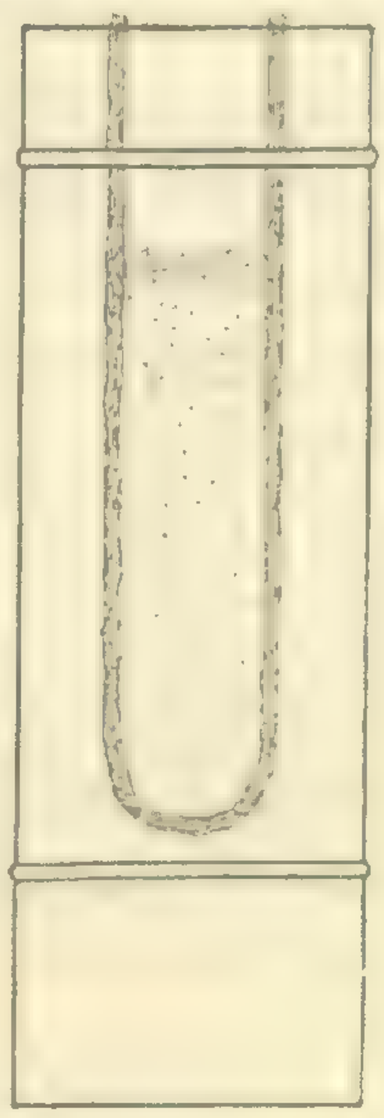

Fig. 1.

Two or three rubber bands — doubled so as to exert more pressure, if the smaller Infusoria are to be kept in it; otherwise not — are passed around the slides crosswise. This arrangement constitutes the U-cell. The darning cotton used should be of such a size as will cause the slides to be about 0.5 mm. apart when the rubber bands have been applied. This dimension and also the length of the U should be so regulated as to admit of the convenient use of a capillary pipette for the withdrawal of organisms. A shorter U should be obtained by the use of shorter slides, not by altering the proportions given above. Under the magnifier any selected individuals can be taken out. To fill the cell, water containing Protozoa is injected with a small pipette into the open end of the U, while the cell stands nearly vertical. A portion of the water will flow out through the cotton yarn, but capillary attraction will keep

sufficient water in it, even if the cell lies horizontal, as for microscopic examination. Moreover, this outflow affords a convenient method of removing the culture water and of renewing the medium at will without the loss of any Protozoa, if the cell is never permitted to overflow at its open end. A large number of organisms may be filled into it by repeated use of the pipette. Another method of filling the cell is to prepare a siphon consisting of a single wetted piece of woolen yarn, one end of which is inserted with a needle into the opening of the U to a depth of about 5 to 10 mm., the other end being put into the supplying Stender dish, elevated to permit the siphon to act. Over the single strand a continuous stream of Infusoria passes into the cell. These increase in numbers as the water passes through the U and escapes.

When it is desired to use higher magnification without removing organisms from the cell, an oblong cover-glass — *e.g.*, 22 × 44 mm. — may be substituted for the upper slide. Cover-glasses being too flexible, they must be braced in order to produce the even pressure upon the underlying thread necessary to retain small and active Infusoria. For this purpose slides are cut transversely into pieces about 5 mm. in width. At each end of the cover-glass one of these is laid across and a rubber band passed over it. At the open end of the U, as before, the ends of the slide and cover-glass must lie directly opposite each other. Such preparations can be conveniently preserved for a long time by standing them in an inclined position inside a low cylindrical vessel, the open ends of the U-slide projecting above the vessel and the lower ends resting against a bottle or a beaker, somewhat smaller than the vessel, placed in its center to serve as a stop.

The vessel may be filled with water to any desired depth. This method of preservation is applicable to organisms whose natural habitat is standing water.

THE U-CELL FOR CIRCULATING MEDIA.

The U-cell may also be used for a circulating medium, as shown in Fig. 2. The cells are placed in a cylindrical glass dish, with their lower ends resting in the angle of the dish.

They are inclined towards an inner vessel placed in the center of the first. The dimensions of the two vessels should be so selected that the upper ends of the cells come in contact with the inner vessel at about 5 mm. below its open end. From the inner vessel water is led by cotton-yarn siphons, *S''*, of appropriate size, into the cells. A constant-level glass siphon, *S'*, is hung over the wall of the outer vessel. This prevents both overflow from the cells and the complete exhaustion of their water. The inner vessel is supplied with water from an elevated bottle placed near by and stoppered with a two-hole cork. One hole carries an air tube, *A*, extending to the bottom. The other carries a siphon tube, *S*, whose outer arm dips below the surface of the water in the

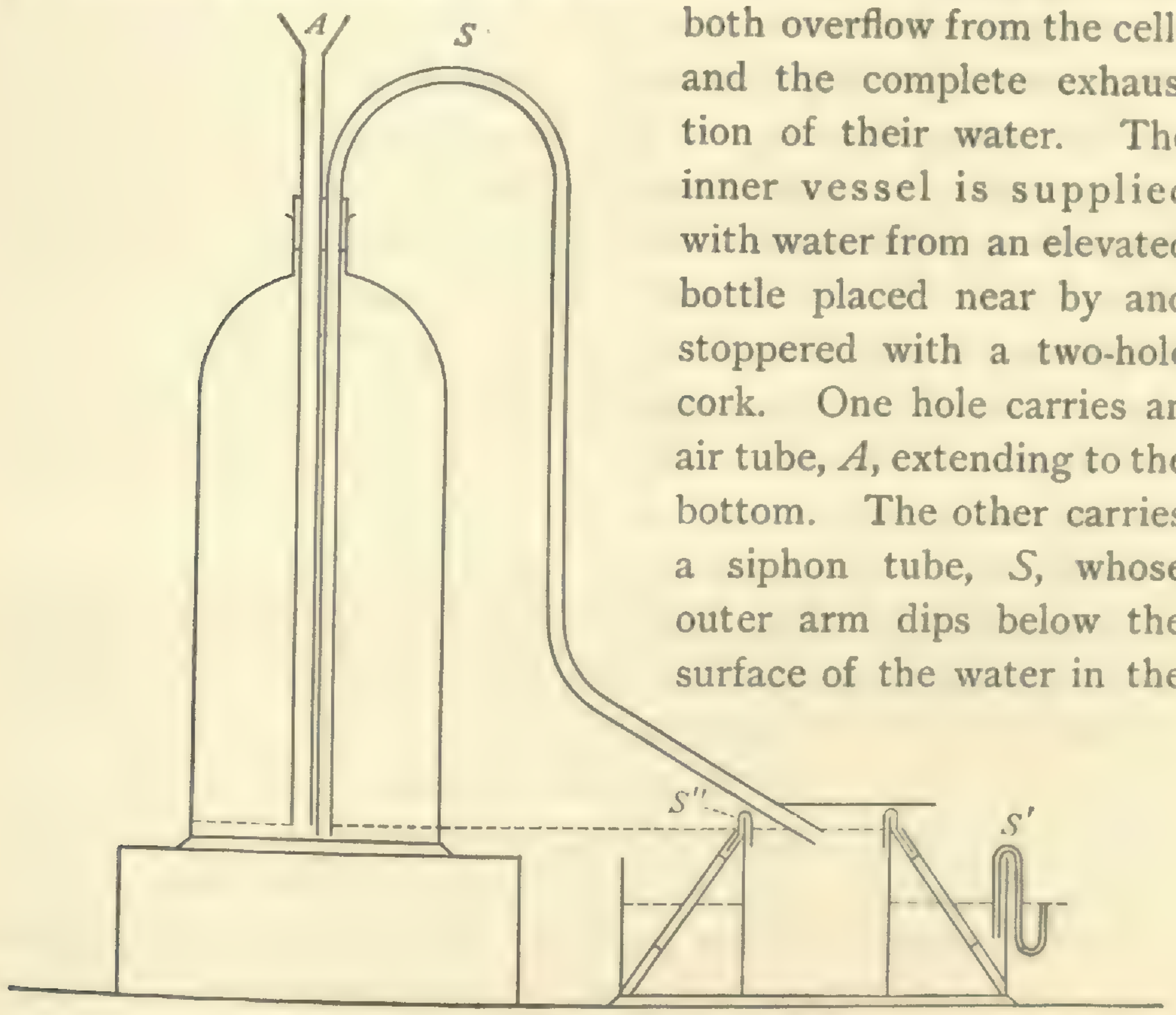

FIG. 2.

inner vessel. With the bottom of the bottle placed a little lower than the level desired for the liquid in the inner vessel, this level can be kept constant by raising or lowering the air tube of the supplying bottle. Then water will pass over the siphon only when the cells withdraw it from the inner vessel. The air tube may conveniently consist of a funnel tube, to be used also for filling the bottle with water. The inner vessel and its yarn siphons should be protected from dust by being covered with a glass plate whose edge is notched to admit the siphon tube. In siphoning, woolen yarn has been used wherever a rapid flow was desired, cotton yarn where a slower rate was needed.

USE OF ABSORBENT COTTON IN MAKING MICROSCOPIC PREPARATIONS.

Temporary or permanent preparations, permitting the frequent change of fluids under the cover-glass that is often required in micro-chemical work, can be made successfully by means of absorbent cotton. This method is very well adapted to the preparation of entire Infusoria. With the forceps a very small quantity of dry absorbent cotton, free from thick masses, is placed in position upon a well-cleaned slide. With a pipette a drop or two of water containing the Infusoria is placed upon the cotton. No more water should be used than can be absorbed by the cotton, which is then spread apart with two needles until the desired thinness of distribution of the fibres is reached. The cotton should occupy about the area of the cover-glass to be used. Both quantity and distribution must be learned by experience. A cover-glass is then lowered horizontally upon the preparation. If a hanging drop is to be transferred to the slide, the cotton is distributed while dry and the cover-glass lowered in the same manner. Two rubber bands, of such size as to exert some but not much pressure, are then passed around the cover-glass, one at each end. Fluids as desired are now passed under the cover-glass by adding them in drops at its upper end when the slide is placed in a more or less slanting position. The fluids emerging from the lower end of the cover-glass are permitted to run down the slide freely, or are guided down by means of a strip of filter paper. When the latter device is used, and with the larger Infusoria, the rubber bands may be removed after the passage of the fixing fluid, and all subsequent fluids slowly added in drops and entirely removed with filter paper, the slide in this case being kept in a horizontal position. In most cases the whole slide, held vertically and with rubber bands in position, may be alternately dipped into and raised out of the fluids to be applied; but balsam had better be added in drops, as above described.

Finally the rubber bands are removed. The cotton properly used is a sufficient mechanical obstruction to prevent the

washing away of any organisms once placed within its meshes. Far less time and care, consistent with the safety of the preparation, are necessary than in the common method of making preparations "under the cover-glass" with the object lying free. At any stage in the process examination is convenient. The preparations can also be stored in the alcohols, etc., if desired. Owing to the use of dry cotton and the horizontal lowering of the cover-glass, the organisms are caught *in the meshes* of the cotton, seldom under or over its fibres. But few if any organisms need be lost, either in this procedure or subsequently. Success depends upon a proper adjustment to each other of the size and quantity of the materials used, and this can be accomplished after a few trials.

CAMBRIDGE, May, 1901.

NOTES ON A SMALL COLLECTION OF MAMMALS FROM THE LIU KIU ISLANDS.

OUTRAM BANGS.

The following notes are on a small collection of mammals from the southern or Yayeyama group of the Liu Kiu Islands, recently acquired by the Museum of Comparative Zoölogy from Alan Owston, Yokohama. The collection was made by Ishida Zensaku in 1899, and comprises but four species, one of which is here described as new.

Our knowledge of the mammalian life of the Liu Kiu Islands is still very imperfect, and apparently but one other mammal — *Caprolagus furnessi* Stone[1] — has been recorded from there. This hare, and the bat here described, however, are additional evidence of the faunal relationship of these islands and Himalaya.

Sus sp.

One specimen of a young pig in the spotted and striped pellage, skull broken. Taken in the island of Ishigaki, April.

Crocidura (Pachyura) cærulea (Kerr).

Three skins with skulls, from Ishigaki, April and June. This shrew is said to be carried about in vessels like the house mouse. It certainly has an immense range throughout which it does not appear to vary.

Pteropus dasymallus Temm.

One adult skin with skull, from Ishigaki, March. Though originally attributed to Japan, this woolly bat is probably confined to the Liu Kiu Islands. Late research has failed to discover it in Japan, while it is known to be common in the islands.

Hipposideros turpis[2] sp. nov.

Three specimens, skins and skulls, from Ishigaki, May 10.

Type: From Ishigaki Island, southern group of Liu Kiu Islands, adult ♀ No. 10003, Coll. of Mus. of Comp. Zoöl. Collected by I. Zensaku, May 10, 1899.

[1] *Proc. Acad. Nat. Sci. Phila.*, Sept. 27, 1900, pp. 460–462.

[2] *Turpis*, ugly, unsightly, — on account of the hideous faces of these bats.

Characters: Most nearly related to *H. armiger* and *H. swinhoei*, but much smaller than either ; vertical ridges on erect portion of nose leaf well developed and free edge of horseshoe entire, characters which agree with the large *H. armiger* and *H. swinhoei;* and not with *H. pratti* and the small *H. leptophylla*, the only other known species with erect portion of nose leaf narrower than horseshoe.

Color and fur: Fur long and fluffy, about 12 mm. long in middle of back ; confined to body, and not extending on the membranes ; on humerus it extends not quite to middle ; on ear it covers a little more than the basal third, and on inner margin in front it extends upward, sparsely, nearly to the top ; in Nos. 10003 and 10004 the basal portion of the fur on back and whole length of fur on lower surface is pale, dull cinnamon ; on lower back and rump the tips of the hairs are much darker — nearly seal brown ; No. 10002 has the under fur darker than in the other two specimens and much more drab in color.

Ears: The ears are large, very broad at base, and tapering abruptly from behind to a point ; posterior surface roughened by many (about eleven) distinct cross ridges.

Muzzle and chin: Arrangement of nose leaf, horseshoe, etc. (so far as can be judged from dry specimens), nearly as in the large *H. armiger*, *i.e.*, erect portion of nose leaf narrower than horseshoe ; vertical ridges on erect portion of nose leaf well developed ; free edge of horseshoe entire.

Measurements: (All external measurements are from the dried specimens.)

Number	Sex	Total Length	Tail Vertebræ	Tibia	Foot	Forearm	Longest Finger	Ear from Meatus	Ear from Crown	Width of Ear
10002	♀	92	36	31	15.5	66	94	25	20	20
10003	♀	95	34	31	15	67	97	24	20	20.5
10004	♂	90	28	31	15	68.5	95.5	26	21	20.5

Skull: No. 10002 ♀, greatest length, 25.2 ; occipitonasal length, 21 ; zygomatic width, 13.6 ; length from front of canine to back of last molar, 10 ; length of mandible, 17.2. The skulls of all three specimens are imperfect, the basal and posterior portions, including the bullæ, having been cut away. The remaining portions agree closely with the skull of *H. armiger*, as do the teeth, except in being very much smaller.

I am indebted to Mr. Gerrit S. Miller, Jr., for assistance in comparing this bat with specimens in the National Museum.

Museum of Comparative Zoölogy,
Cambridge, Mass.

CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE. E. L. MARK, DIRECTOR. No. 125.

A CASE OF INCOMPLETE DUPLICATION OF PARTS AND APPARENT REGULATION IN NEREIS VIRENS SARS.

C. W. PRENTISS.

ALTHOUGH during the past few years numerous instances of complete bifurcation have been recorded in various annelids, I know of no case where intermediate conditions, or incomplete duplication of parts, have been observed. Among several hundred specimens of Nereis collected for class dissection in November, 1899, an individual was discovered apparently exhibiting an abnormality of this kind, and it was therefore deemed worthy of special study and a brief description.

The specimen we are to describe (Fig. 1), a sexually mature male, was collected at the mouth of the Saugus River near Lynn,

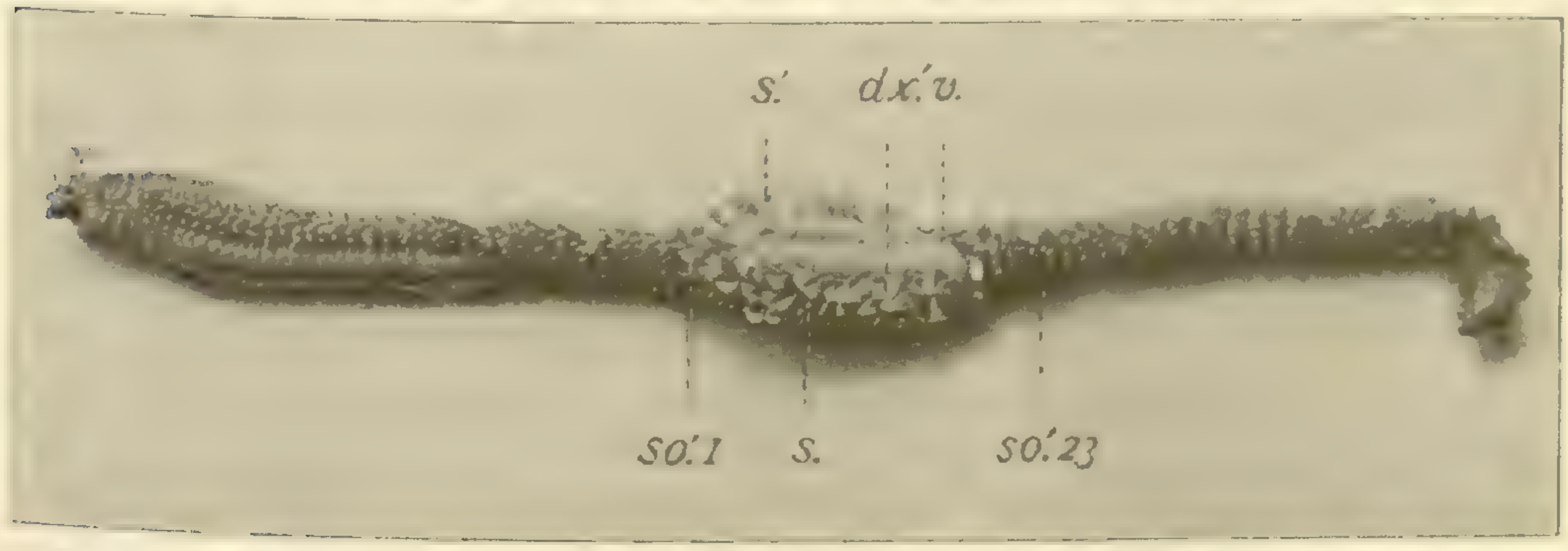

FIG. 1. — View of the left side of an abnormal Nereis, showing the interpolated region. Natural size.) *dx.'*, right abnormal parapodium; *s.*, left normal parapodium; *s.'*, left abnormal parapodium; *so.' 1*, first abnormal metamere; *so.' 23*, last abnormal metamere; *v.*, posterior limit of the abnormal ventral region.

Mass. It measured 11.5 cm. in length when fully extended, and, except for the region near the middle of its body, was perfectly formed externally. The variation from the normal was, unfortunately, not observed until after the worm had been killed

by the ordinary method employed for laboratory material, and as a result the preservation of the tissues was not of the best. After photographing the animal from the left or abnormal side, three entire metameres from different points along the abnormal region were carefully removed by free-hand sectioning, mounted in balsam, and studied as whole preparations. The remainder of the worm was then imbedded in paraffin and a series of transverse sections obtained which enabled one to trace the different organs through the entire length of the specimen.

The abnormality, as seen in Fig. 1, is confined to twenty-three median somites. Not only is the diameter of the body much greater in this region than it is either anterior or posterior to it, but the number of parapodia to each segment is also increased. An extra pair of appendages is present on the forty-first metamere, or first abnormal somite (Fig. 1, *so.' I*), of the worm. Immediately anterior to this somite there is evidence of a cicatrix ; the fortieth metamere, however, is apparently normal, and the interpolated parts make their appearance abruptly and in a fully developed condition. Looking at the left side of the animal, as in Fig. 1, three series of parapodia are seen. Two of these rows (*s.* and *dx.'*) are closely approximated and ventral in position ; the third set (*s.'*) is dorsal and separated from the other two by a region which, from its longitudinal furrow and general external appearance, might be taken for the true ventral side of the worm. This condition persists from the forty-first to the fifty-fourth metamere inclusive (fourteen somites), the pseudo-ventral region gradually becoming smaller and finally disappearing at *v.* As a natural result of its disappearance, the two series of parapodia (*s.'* and *dx.'*) approach each other until at about the seventeenth abnormal somite (*v.*) the appendages *s.*, *dx.'*, and *s.'* are close together. Parapodia *s.'* and *dx.'* of this metamere are much smaller than *s.*; their size is further reduced in the next six metameres, and in the twenty-third the last evidence of abnormality is to be observed. Externally at least, the somite segments of the animal are normal.

Examination of complete metameres in transverse section shows better the relations of the external parts and at the same

time brings out the structural conditions of the internal organs in the abnormal region. In the sixth abnormal metamere (Fig. 2) the two pairs of appendages are arranged symmetrically, *dx.* and *s.'* being lateral and in normal position, while *s.* and *dx.'*, placed back to back, project downward, or in a normal ventral direction. But there is apparently a well-developed ventral region on either side of these parapodia (*s.* and *dx.'*). At first glance it is difficult to tell which is the normal ventral side and which the interpolated part. In each

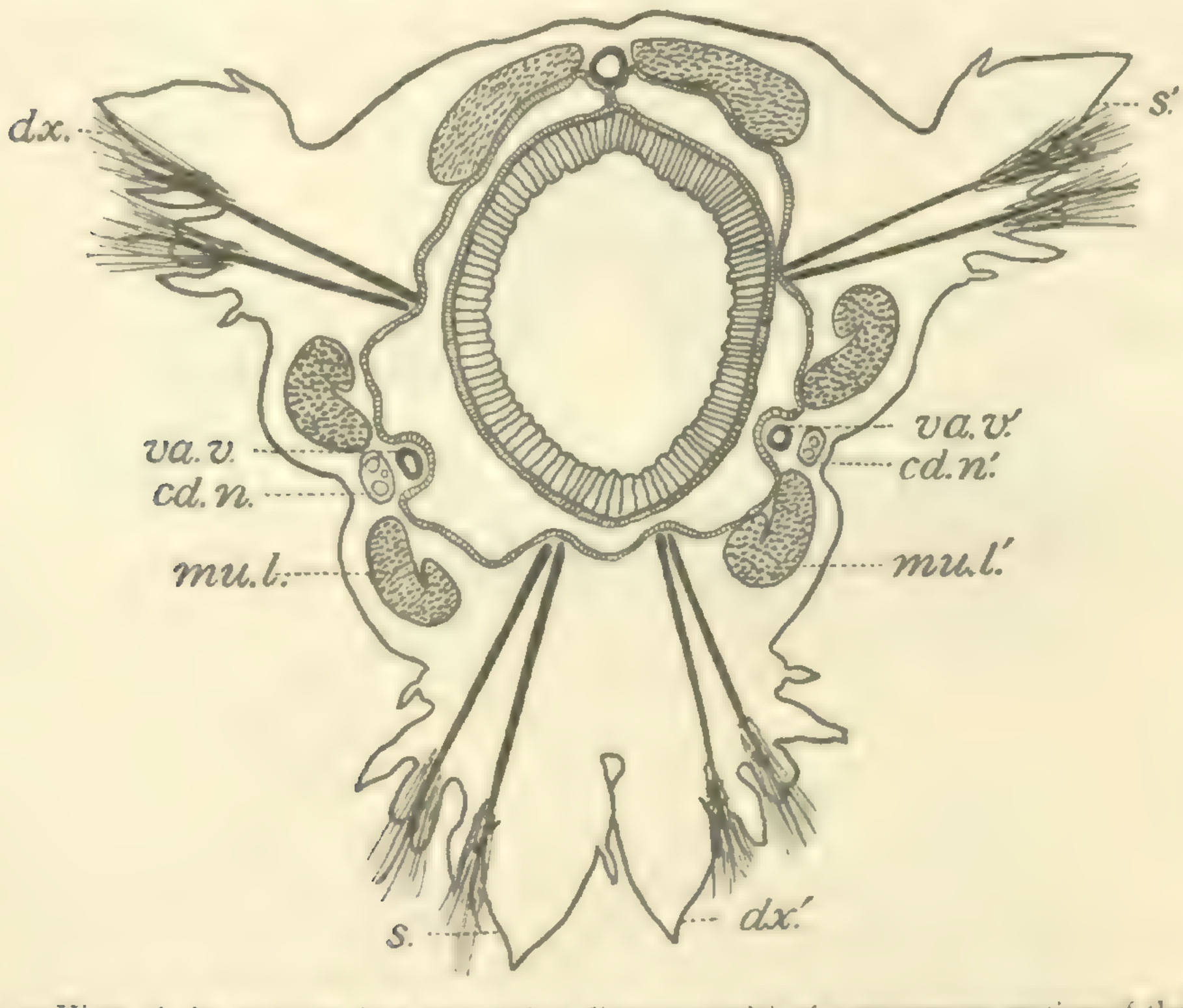

FIG. 2. — View of the anterior face (somewhat diagrammatic) of a transverse section of the sixth abnormal somite. (× 6.) *cd.n.*, *cd.n.'*, nerve cords; *dx.*, right normal parapodium: *dx.'*, right abnormal parapodium; *mu.l.*, *mu.l.'*, longitudinal ventral muscles; *s.*, left normal parapodium; *s.'*, left abnormal parapodium; *va.v.*, *va.v.'*, ventral vessels

region there is a well-formed nerve cord (*cd.n.*, *cd.n.'*), flanked by a pair of longitudinal muscles (*mu.l.*, *mu.l.'*). The slightly smaller size of the parts on the right of the figure (the left side of the worm) is the main indication that this portion has been interpolated.

On examining the parapodia of this somite more minutely, we find that they are all normal in every part. Indeed, *dx.* and *s.'* might be taken for the normal pair, if *s.'* and *dx.'* were not slightly smaller than *s.* and *dx.* That these latter, however, are the normal appendages is plain from the conditions found

in the eighteenth abnormal somite (Fig. 3). At this point the ventral longitudinal muscles and nerve cord of the abnormal side have disappeared, and the parapodia *s.'* and *dx.'* are in close proximity, their inferior ligulæ nearly touching each other. They are now noticeably smaller than in Fig. 2 ; *s.* and *dx.*, on the other hand, have remained constant in size, but *s.*, no longer projecting ventrally, has swung around into a more lateral position on the left side of the median plane. As a result, the ventral surface of the animal is now more nearly parallel to the dorsal surface. Except for the absence of ventral cirri, *s.'* and *dx.'* still possess all their normal parts, but the relative size of

FIG. 3. — View of the anterior face of a section through the eighteenth abnormal somite and its appendages. (× 6.) *cd.n.*, nerve cord; *dx.*, right normal parapodium; *dx.'*, right abnormal parapodium; *mu.l.*, longitudinal ventral muscles; *s.*, left normal parapodium; *s.'*, left abnormal parapodium; *va.v.*, ventral blood vessel.

these parts is such as is characteristic of parapodia which are in process of development, rather than of fully formed appendages. This condition of arrested development is most noticeable in the ligulæ of the dorsal rami, which are disproportionately small as compared with those of the normal appendages of this metamere.

Tracing this same series of appendages (*s.'* and *dx.'*) back into the twenty-first abnormal somite (Fig. 4), they appear still further reduced. In appendage *dx.'* the dorsal ramus is small, and its inferior ligula is wanting. The ventral ramus is apparently represented by only the inferior ligula and aciculum. Appendage *s.'* is even more rudimentary, being represented by

only two projections, both of which belong to the dorsal ramus; the smaller is the dorsal cirrus, and the larger one the superior ligula of the dorsal ramus. Both acicula, as well as the ventral ramus, are wanting. In the third metamere posterior to this section, as we have seen from an examination of the exterior, the normal structure is once more regained.

Throughout the abnormal region the musculature of the body wall and that of the appendages are well developed in the interpolated portion. In the body wall of the interpolated part circular, longitudinal, and oblique muscles are found. The circular band is continuous with that of the normal portion of each metamere. The supernumerary longitudinal muscles

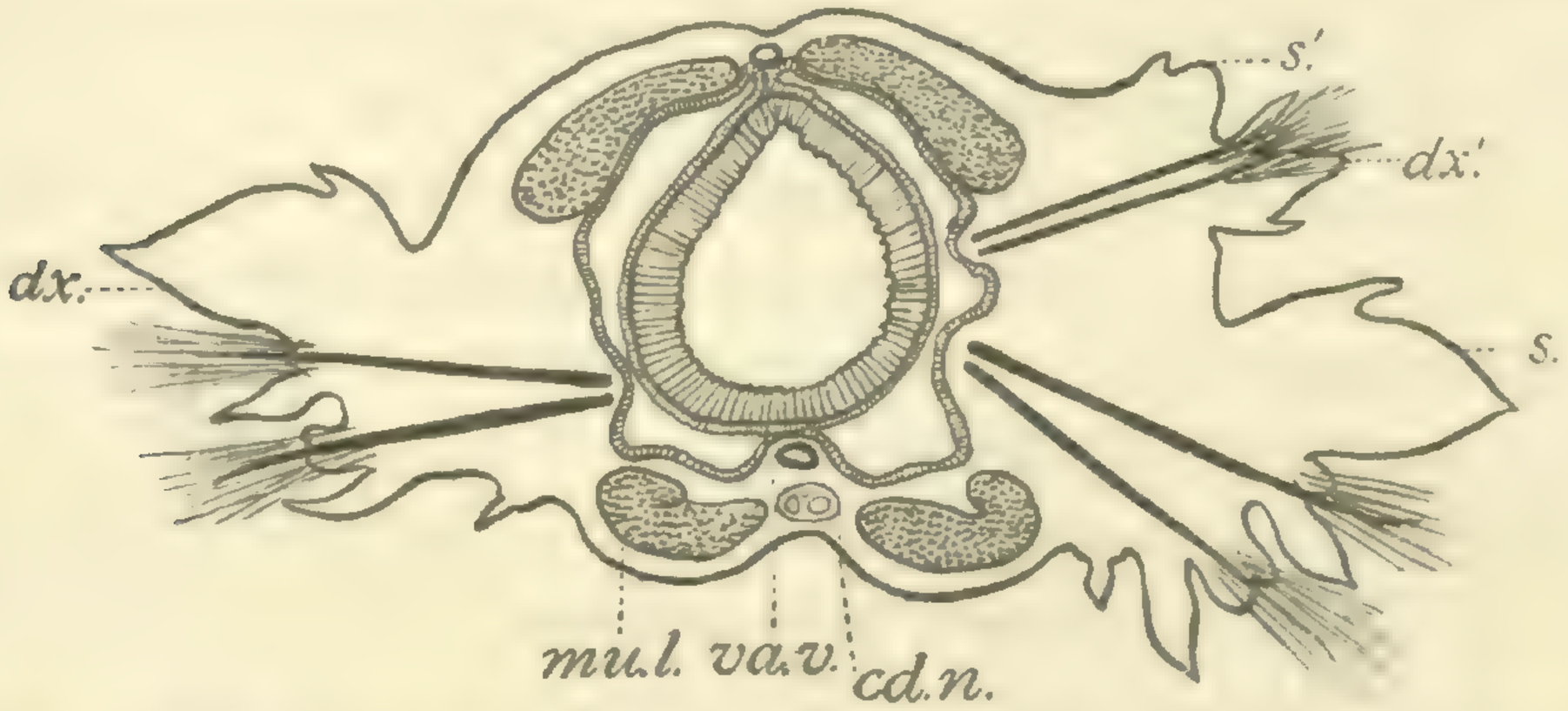

FIG. 4. — View of the anterior face of a section through the twenty-first abnormal somite and its appendages. (× 6.) *cd.n.*, nerve cord; *dx.*, right normal parapodium; *dx.'*, right abnormal parapodium; *mu.l.*, longitudinal ventral muscles; *s.*, left normal parapodium; *s.'*, left abnormal parapodium; *va.v.*, ventral blood vessel.

(Fig. 2, *mu.l.'*) have in cross-section the peculiar kidney shape characteristic of the normal longitudinal ventral muscles. They appear as small strands of fibres in the first abnormal metamere, and are attached to the circular muscle fibres of that region. They attain their greatest development in the next few somites, and after extending back through fifteen metameres are gradually reduced in size and finally disappear. Sets of oblique muscles are also found in those segments in which the extra, ventral longitudinal muscles are present. Parapodial muscles are attached to the proximal ends of the acicula, as is usual in normal appendages.

The intestinal canal shows no particular irregularity of form. There is no sign in the abnormal metameres of even partial division, but its size is remarkedly increased throughout this region.

Immediately above the abnormal nerve cord (*cd.n.'*) is an extra ventral blood vessel (Fig. 2, *va.v.'*). Beginning in the second interpolated somite, it can be traced back through the twelve succeeding metameres. Anteriorly it is connected by branches with the normal dorsal and ventral blood vessels and gives off ramifications to the organs of the interpolated region. Posteriorly there is no such direct communication with the normal blood vessels, and twigs from the normal vessels supply a portion of the blood to the extra parts in this region. In the last seven or eight abnormal somites this ventral vessel is absent and the interpolated parts receive their entire blood supply through small branches from the normal vessels. In each somite throughout the abnormal region a large branch of the dorsal blood vessel runs around the *left* side of the intestine directly to parapodium *s.*, passing the interpolated parts. As its main trunk enters this appendage it gives off a good-sized twig to *dx.'* Parapodium *dx.'* thus receives a better (double) supply of blood than *s.'*, and Figs. 3 and 4 show that *dx.'* is also better developed than *s.'*

The abnormal nerve cord (Fig. 2, *cd.n.'*) shows several interesting peculiarities. It has no direct connection with the main nerve cord, and it is normally situated with reference to the interpolated parts, lying between the two supernumerary longitudinal muscles. Its anterior end is found in the second abnormal metamere, whence it can be traced back through fifteen somites. Like the normal cord, it is supported by a network of neuroglia tissue, the whole being enclosed in a fibrous neurilemma sheath, which is thicker at the anterior than at the posterior end. A transverse section through this cord in the region of the third abnormal metamere exhibits the conditions shown in Fig. 5. There are eight small masses of neuropil, surrounded ventrally and laterally by groups of large

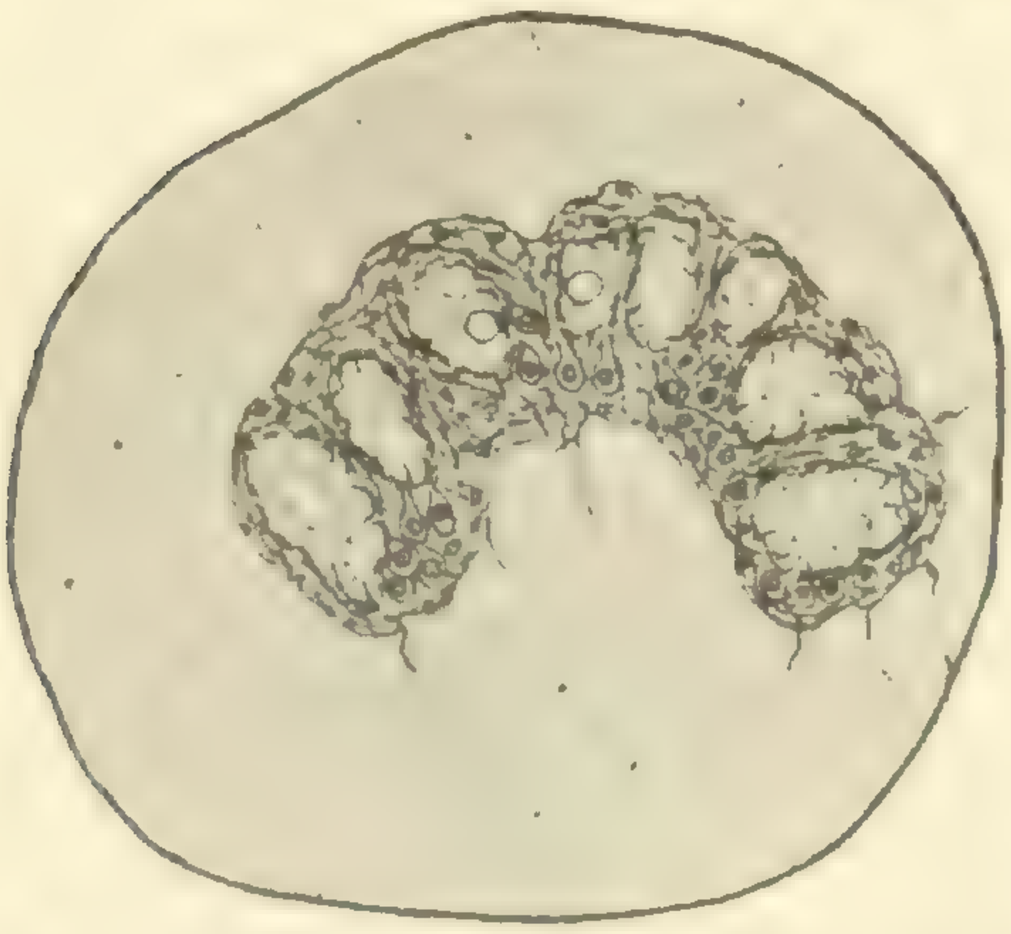

FIG. 5. — View of the anterior face of a transverse section through the anterior part of the abnormal nerve cord. (Dorsal is up in the figure.) (× 60.)

unipolar ganglion cells. The ganglionic masses can be followed continuously through three metameres. Four pairs of large nerves are given off from this portion of the cord to the supernumerary parapodia and the body wall. This ganglion measured 0.6 mm. through its widest part, which is 0.2 mm. more than the greatest diameter of any normal ganglion from the same region. There is thus an evident centralization of nerve substance at the anterior end of the abnormal cord, comparable perhaps to the centralization found in the subœsophageal ganglion of the normal nervous system. Throughout the remainder of the interpolated nerve chain there are two longitudinal connectives with a ganglionic enlargement in each of the twelve succeeding metameres. Fig. 6 is a transverse section through one of these ganglia. The connectives and ganglia are small, taper gradually at the posterior end, and terminate independently. Three of the ganglia averaged 280 μ in greatest diameter, while the longitudinal connectives varied from 300 μ, at the anterior end of the chain, to 125 μ, near the posterior end. The normal connectives and ganglia of the same region measured respectively 300 μ and 400 μ in diameter. Five pairs of nerves are given off latero-ventrally from each ganglion and connectives to the adjacent metameres. This agrees with the number of pairs innervating each normal somite of the worm. In addition to their small size the connectives present another peculiarity in the absence of the three giant fibres, which are such conspicuous structures in the normal cord.

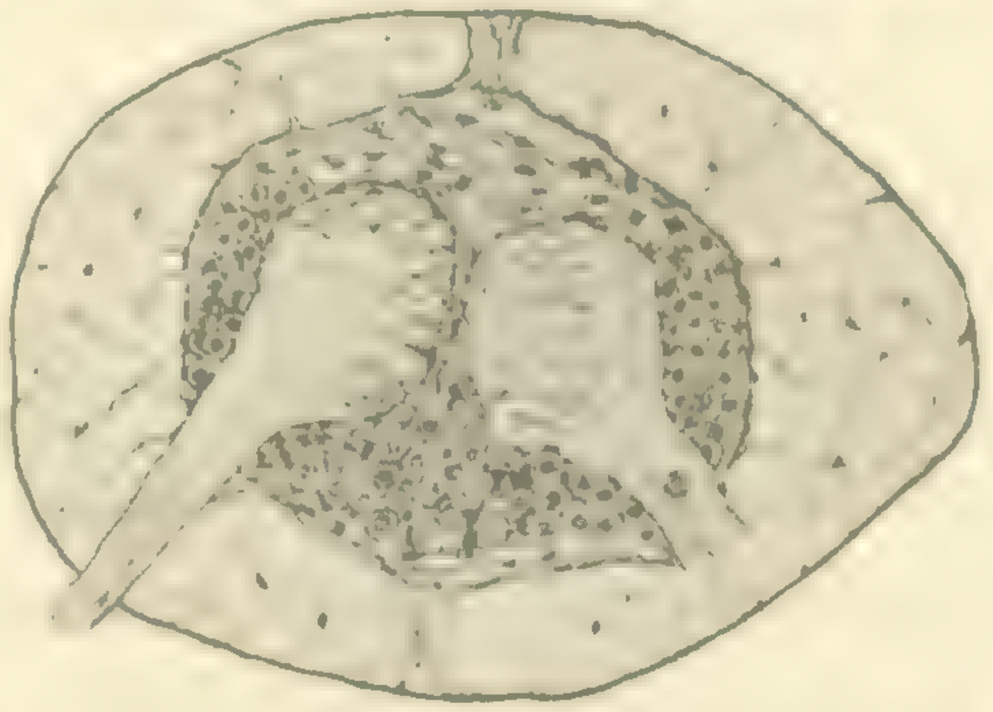

FIG. 6. — Anterior face of a transverse section through the seventh abnormal ganglion; showing neuropil, ganglion cells, and 4 pair of parapodial nerves. (× 60.)

From the above description of the animal we find (1) that the abnormality is serial in its occurrence, makes its appearance abruptly, and extends through twenty-three somites; (2) interpolated in each of the first twelve abnormal metameres is a pair of appendages, together with all the organs which, in the normal animal, are included ventrally between the parapodia;

(3) within the next eleven somites the supernumerary parts gradually diminish in size and disappear; (4) the presence of a slight cicatrix, anterior to the first variable metamere, indicates that the abnormality resulted from an injury received at a point where the development of new somites was in progress.

The structural conditions which we have found to exist in this instance of partial duplication of parts throws light on the cases of complete bifurcation of the posterior end which have been frequently observed in annelids.

Among the Lumbricidæ Robertson ('67) figures and describes a specimen of *Lumbricus terrestris*, the body of which is forked at the eighty-fifth somite. Each portion of the fork begins with a perfect somite, and both are borne on a single large metamere. A branch of the bifurcated intestine, of the chief blood vessel, and of the nerve trunk, is contained in each terminal, and the sexual organs are also fully developed.

Bülow ('83), experimenting upon the regeneration of lost parts in *Lumbriculus variegatus* Gr., discovered among the animals which he operated upon several specimens possessing two well-formed tails. In one individual 5.5 cm. long the so-called tails were 1.75 cm. in length.

Bell ('87) noted a case of bifurcation at the posterior end in *Nereis pelagica*, but gave no detailed description.

Andrews ('92, '94) has devoted special study to bifid annelids. His first paper ('92) reviews the literature of the subject, and describes among polychætes, in the family Syllidæ, an individual of the species *Procærea tardigrada* Wb., which possessed two tails of nearly equal length. In his second paper ('94) he figures and describes two cases of the bifid condition in the oligochæte *Allolobophora fœtida*, and eight cases of a similar abnormality in the polychæte *Podarke obscura*. In the ten specimens described there was at the posterior end complete duplication of the main axis of the body and all its appurtenances. The only exception was an earthworm in which the digestive tract was absent in one of the tails. In five out of eight specimens of Podarke one of the terminal parts had no

direct nervous connection with the hind end, although a well-formed nerve cord was present in the tail itself. This condition of the nervous system thus closely resembles that which we have here described in Nereis.

Andrews thinks that the balance of evidence favors the conclusion that these cases of bifurcation may be produced in the adult by traumatic interference ; all the conditions may be thus explained, and some can be accounted for in no other way. But though he performed many regeneration experiments on both earthworms and Podarke, no duplications were produced. This, however, he does not consider astonishing, as examples of bifurcation are extremely rare under natural conditions, although loss of parts followed by regeneration is constantly taking place.

Andrews accounts for the independent condition of the nerve cords in the bifurcated specimens of Podarke by assuming that the short isolated part represents a piece formerly connected with the main nerve cord, which has failed to reunite with it. To quote his own words : "We naturally suppose here that a wound has healed over in such a fashion that the old nerve cord does not reunite, but that the distal end remains as an isolated stump, while the proximal end grows down into the new terminal that is formed, abnormally, in place of the injured tissue, or at the place of injury to the tissue of the normal terminal."

The conditions which we have described in the interpolated nerve cord of Nereis do not allow the application of Andrews's assumption. The abnormal nerve chain does not extend into the normal somites anteriorly, but is wholly restricted to the interpolated region, and must therefore have been formed after the assumed injury to the worm ; then, too, its finer structure differs from that of the main nerve cord, more especially at the anterior end, where we should expect to find it most closely resembling the normal cord if it represented a detached portion of it. In this Nereis, therefore, the interpolated nerve cord undoubtedly developed as an independent structure.

It is well known that in nearly all annelids the cells of each metamere behind the head region possess the latent power

of regenerating new somites in case of their accidental loss. *Syllis ramosa*, a remarkable annelid described by M'Intosh ('85), is not only capable of forming terminal somites, but also of producing lateral buds. The branches of the main axis thus formed may again bud, forming a complex system, any ultimate tip of which may be constricted off and develop into a sexual animal. In this case a portion only of a somite may give rise to a perfect individual. As Andrews has pointed out, lateral budding in Syllis, and bifurcation of the posterior end in Lumbricus, are undoubtedly merely different manifestations of the same phenomenon. In the budding, duplications of the main axis are formed at successive periods ; in bifurcations of the body, the duplications are formed simultaneously. In both cases a sexual animal exhibits the power of reproducing itself by means of a vegetative process.

It is easily conceivable that, as a result either of injury to the anal somite, or loss of caudal metameres, two regions of regeneration might be formed instead of one. If these formative areas are entirely independent of each other, their continued growth would produce a bifurcated condition, and Bülow ('83) occasionally found this to be the case in regenerating earthworms. If, however, the separation of the two areas of regeneration is incomplete, the duplication of the new metameres would be only partial. Thus, in the Nereis which we have described, injury to the anal somite (when it was the forty-first metamere of the worm), or accidental loss of a few somites posterior to the fortieth, might, on regeneration, have produced the incomplete duplication of the metameres. That this may be the true explanation of the abnormality seems very probable, but further (experimental) evidence is needed to demonstrate it beyond a doubt.

It would seem a more difficult task to account for the gradual diminution in size and final disappearance of the interpolated parts. The changes which brought about such a return to the normal condition could have taken place only in the anal metamere, for it is there that the fundament of each new somite is laid down. The gradual process of reconstruction which must have taken place in the formative tissue may be compared

to the phenomenon of regulation observed by Rand ('98, '99), by which the more primitive cœlenterate, *Hydra viridis*, rids itself of supernumerary structures produced by abnormal regeneration. This inherent regulative power may have been assisted in the worm by arrested development of the interpolated parts due to a deficient blood supply. The structure of the abnormal parapodia, as we have seen, warrants the assumption that their development is incomplete, and the defective condition of the vessels supplying these appendages strongly indicates that lack of sufficient nourishment was the cause. Such a defect in the vascular system, however, could merely aid in the reduction of the abnormal parts; their total disappearance must be due primarily to the profound regulative changes which took place in the reproducing anal metamere.

Such a strong inherent tendency toward the production of a constant and normal condition undoubtedly accounts for the infrequent occurrence of abnormalities in regenerating worms. In most cases of injury, where regulation becomes necessary, the process is probably completed before the formation of new somites begins. When, on account of a specially serious injury, the process is delayed, partial duplications may be formed, but the regulative changes may still go on to completion and the normal condition be finally established, as in the present case. If, however, the traumatic influence is so profound as to give rise to separate regions of regeneration, regulation may take place in each and produce two normal series of metameres, but an abnormal bifurcated worm.

From our description of this single case of abnormality in Nereis, and comparison of its structure with that found in bifid Polychæta, we may conclude:

1. That a single metamere of a polychæte annelid may give rise to a complete or partial duplication of the main axis of the body.

2. The production of these abnormalities in all probability takes place in the post-embryonic worm, and is due to traumatic stimulus.

3. The supernumerary, and in some cases useless, parts thus formed may be gradually suppressed by regulative changes

which take place in the formative segment and tend to restore it to the normal.

In conclusion I wish to express my thanks to Professor E. L. Mark for most helpful suggestion and criticism.

CAMBRIDGE, MASS., May 24, 1901.

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SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XIV. The Hydromedusæ — Part III.

CHARLES W. HARGITT.

Medusæ.

The Medusæ (medusoids, medusiform persons, gonophores, gonozooids) of this class of cœlenterates may be designated as in general of the form of a more or less transparent bell, or saucer-shaped disk, varying in size from the almost microscopic to organisms of fifteen inches or more in diameter.

The comparison of the medusa with a bell is fairly good, its body being similar in form in typical cases to the body of the bell, the manubrium corresponding to the clapper. A similar comparison with an umbrella is almost equally appropriate, if not superior. In this case the body of the medusa would correspond to the extended disk of the umbrella, the manubrium to the handle, and in some respects the radial canals are comparable with the ribs of the umbrella, while the numerous tentacles of some species are somewhat comparable with the marginal fringe often seen upon a lady's parasol. In further keeping with this comparison the outer, aboral portion of the medusa bell has been designated as the exumbrella, the inner, concave portion of the bell as the subumbrella. The mouth is located at the terminal, pendent portion of the manubrium, and through the tubular canal as an œsophagus communicates with the gastric pouch or stomach, from which radiate the gastric or chymiferous canals, by means of which the digested food matter is distributed over the body and through the circular or circumferential canal to the marginal organs.

At first sight there might seem to be little in common between the medusa and hydranth, either as to form, structure,

habit, etc.; but a closer scrutiny will reveal so intimate a fundamental likeness in all essentials as to demonstrate clearly the homological equivalent of every feature, some of the accessory or sensory structures alone excepted; and since these are not constant features they may clearly be disregarded in the comparison. Differences as to form and habits may be considered as adaptations to the characteristic functions of a free and motile organism.

In keeping with the synopsis of orders already given, that of the several families and genera of Medusæ will be taken up in their respective order.

ANTHOMEDUSÆ.

The Anthomedusæ are generally of more or less hemispherical form or sometimes of an elongate or subconical outline. All are possessed of a definite, muscular velum; sensory organs or ocelli borne on bulbs located at the bases of the tentacles, about which there is usually a colored pigment rendering them quite conspicuous, are usually present; otocysts are not present. The radial canals are generally four in number, rarely six or eight; gonads are developed and borne on the walls of the manubrium.

SYNOPSIS OF FAMILIES.

I. CODONIDÆ. Mouth-opening simple, devoid of tentacles or lobings: gonads not radially divided, but forming a circular, continuous tissue about the manubrium; marginal tentacles unbranched.

II. TIARIDÆ. Mouth-opening provided with simple or frilled oral lobes; with four or eight distinct manubrial gonads; marginal tentacles unbranched.

III. MARGELIDÆ. Mouth-opening surrounded with four or more simple or branched oral tentacles; four or eight manubrial gonads; marginal tentacles unbranched.

IV. CLADONEMIDÆ. Mouth-opening rarely simple, usually provided with oral lobes or tentacles; marginal tentacles variously feathered or branched.

Key to the Genera.

CODONIDÆ.

A. With two or four marginal tentacles, equally developed.

1. Tentacles and manubrium long and slender, the latter extending much beyond the velum; bell hemispherical . . . . Coryne
2. Tentacles rather short, stout, and capitate; manubrium extending but slightly beyond velum; bell conical . . . . . Dipurena
3. Tentacles rather stout and closely coiled, bell elongate hemispherical and with eight rows of nematocysts . . . . . Ectopleura
4. Tentacles only two at liberation, four in maturity . . Hydrichthys
5. Tentacles very rudimentary, bell oblong . . . . . Pennaria
6. Bell hemispherical, with slight conical apical projection, tentacles two, often coiled within bell when disturbed . . . Perigonimus

B. With a single conspicuous tentacle, others unequally developed or rudimentary.

1. Large tentacle stout and triangular, other three rudimentary; manubrium short and thick . . . . . Euphysa
2. A single large and long tentacle, two very small, and one rudimentary; bell hemispherical and slightly asymmetrical Corymorpha
3. Bell evidently asymmetrical; a single very large tentacle with enlarged base, from which bud proliferously secondary medusæ, other tentacles very rudimentary . . . . . Hybocodon

TIARIDÆ.

A. Marginal tentacles two, opposite.

1. Bell with rather pointed apical projection . . . . . Stomotoca

B. Marginal tentacles numerous.

1. Bell with large, globular, apical process . . . . . Turris
2. Bell without globular apical process . . . . . Turritopsis

MARGELIDÆ.

1. Marginal tentacles eight, symmetrically distributed { Dysmorphosa / Podocoryne
2. Marginal tentacles eight, rudimentary . . . . . Stylactis
3. Tentacles in eight clusters . . . . . Lizzia
4. Tentacles in four clusters . . . . . Bougainvillia
5. Tentacles in four clusters, each with an erect clavate pair Nemopsis

CLADONEMIDÆ.

A. Radial canals simple.

1. Marginal tentacles two, fringed with stalked nematocysts, bell with subconical apical projection . . . . . Gemmaria
2. Tentacles as in 1, bell hemispherical, without projection Corynitis

B. Radial canals branched.

Marginal tentacles in eight pairs . . . . . Willia

Coryne mirabilis Ag. (FIG. 33).

Bell elongate hemispherical, four to six mm. in diameter; manubrium very long, protruding far beyond the velum, but highly contractile; tentacles likewise very long and filamentous, but capable of great contractility; gonads borne upon body of manubrium and at maturity filling entire bell cavity or even protruding beyond the velum. Fairly common during early spring and summer, swimming near the surface. Hydroid generation, — *Ibid.*

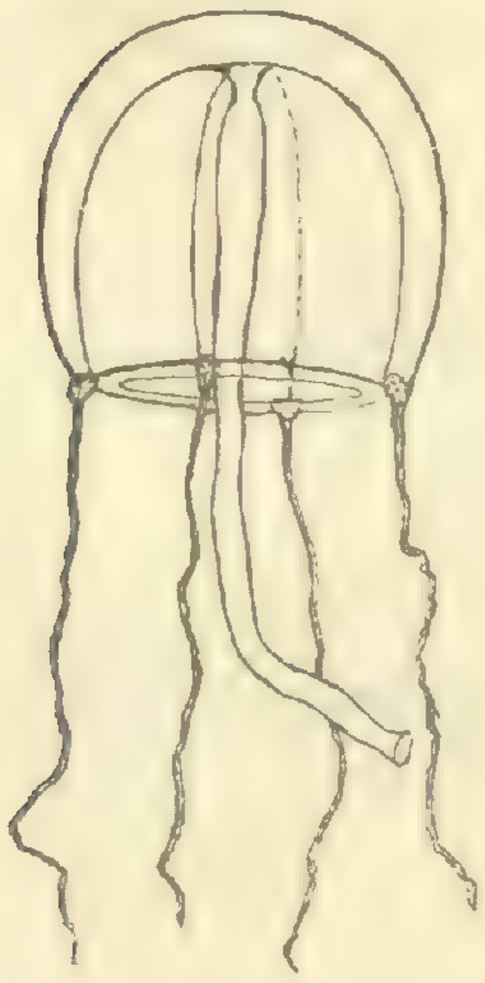

FIG. 33.

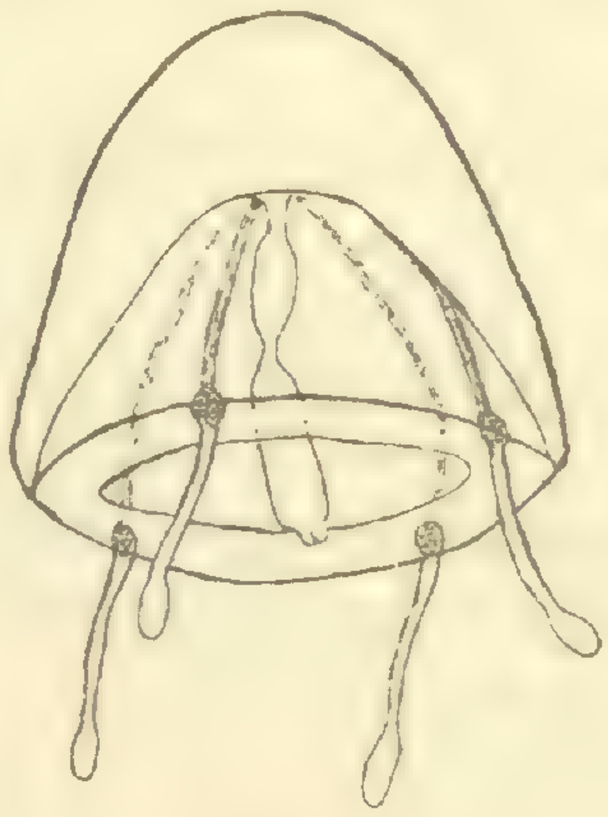

FIG. 34.

FIG. 33. — *Coryne mirabilis* Ag.
FIG. 34. — *Dipurena conica* A. Ag.

Dipurena conica A. Ag. (FIG. 34).

Bell conical or subhemispherical; marginal tentacles four, rather thick and with knob-like ends, and with prominent basal bulbs, each with a single ocellus; manubrium elongate, often extending beyond the velum, the basal portion constricted or narrowed, gastric cavity small, oral opening plain. Size from three to four mm. Common during midsummer. Buzzards Bay, Vineyard Sound, etc.

McCrady (*Proc. Elliott Soc.*, Vol. I) describes from Charleston Harbor two other species of Dipurena, namely, *D. strangulata* and *D. cervicata*, but I find no record of them as occurring elsewhere.

Ectopleura ochracea A. Ag. (FIG. 35).

Bell elongate hemispherical, of nearly uniform thickness, except at the aboral pole, which becomes somewhat conical and correspondingly thicker. In size the medusa varies from four to six mm. Marginal tentacles four,

from the base of which lines of nematocysts extend over the bell to the apex; tentacular bulbs of purplish orange color and each with an ocellus; manubrium rather large and spindle-shaped, of yellowish color.

Hydricthys mirus Fewkes.

Bell oval or subspherical, its outer surface dotted with nematocysts; radial canals four, wide; marginal tentacles four in mature specimens, only two in specimens at liberation; tentacular bulbs reddish in color but without ocelli. The original description was from specimens taken from a colony attached to a fish taken at Newport; other than this I find no records of it. (Cf. *Bull. Mus. Comp. Zoöl.*, Vol. XIII, p. 224.)

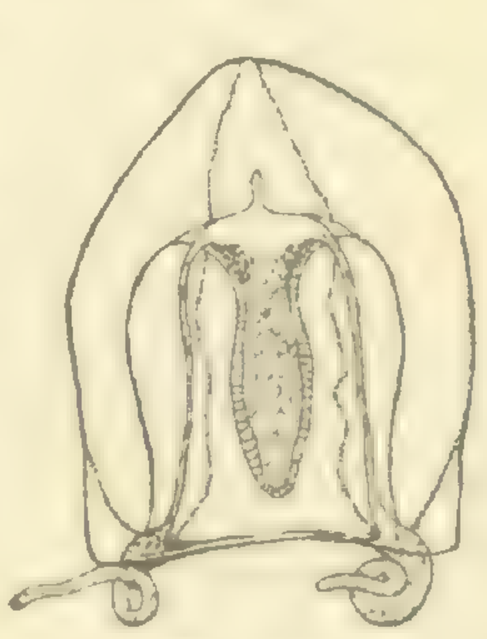

FIG. 35.

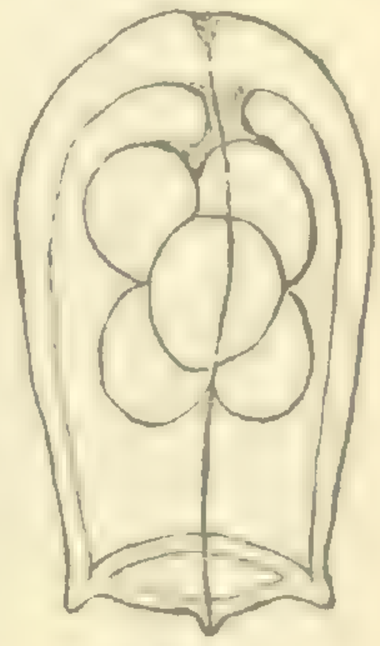

FIG. 36.

FIG. 35. — *Ectopleura ochracea* A. Ag. (After A. Agassiz.)

FIG. 36. — *Pennaria tiarella* McCr.

Pennaria tiarella McCr. (FIG. 36).

Bell oblong oval, of small size, about two mm. in height and half as broad; radial canals four, narrow, but rather conspicuously marked by lines of pinkish pigment; marginal tentacles very rudimentary from the four tentacular bulbs, which are devoid of ocelli: gonads borne on the walls of the manubrium, and as they approach maturity filling the entire cavity of the bell. The eggs and sperms are discharged promptly upon the medusa becoming free and even before; indeed, in many cases the medusæ are never liberated, as I have elsewhere shown. Color of a general reddish pink or rosy, manubrium a chocolate brown; ova vary in color from pale creamy white to rather bright orange.

Specimens of *P. gibbosa* from Florida and Porto Rico seem to me to be scarcely distinguishable from *P. tiarella*. Hydroid, — Pennaria.

FIG. 37. — *Perigonimus jonesii.*

Perigonimus jonesii Osborn and Hargitt (FIG. 37).

(*American Naturalist*, 1894, p. 27.)

Bell hemispherical, with slight conical apical projection; marginal tentacles two, with four marginal bulbs; tentacles highly retractile and often withdrawn and coiled within the bell cavity when the medusa is irritated. Though these medusæ were kept under observation for several weeks, no gonads were developed.

Habitat: Found upon the legs and abdominal somites of the common crab, Labinia, from which it was repeatedly taken during several seasons. Hydroid, — Perigonimus.

Euphysa virgulata A. Ag.

Bell elongate oval, or quadrangular in outline; tentacles rather heavy and unequally developed, one being much longer and heavier than the others; bases with a pinkish band extending upward along the radial canals for a short distance; manubrium cylindrical with simple oral margins and of yellowish color; gonads upon the sides of manubrium. In size the medusa is from ten to twelve mm. in diameter, of rather active habit and fairly common. Nahant, Massachusetts Bay, and southward.

Corymorpha pendula Ag. (FIG. 38).

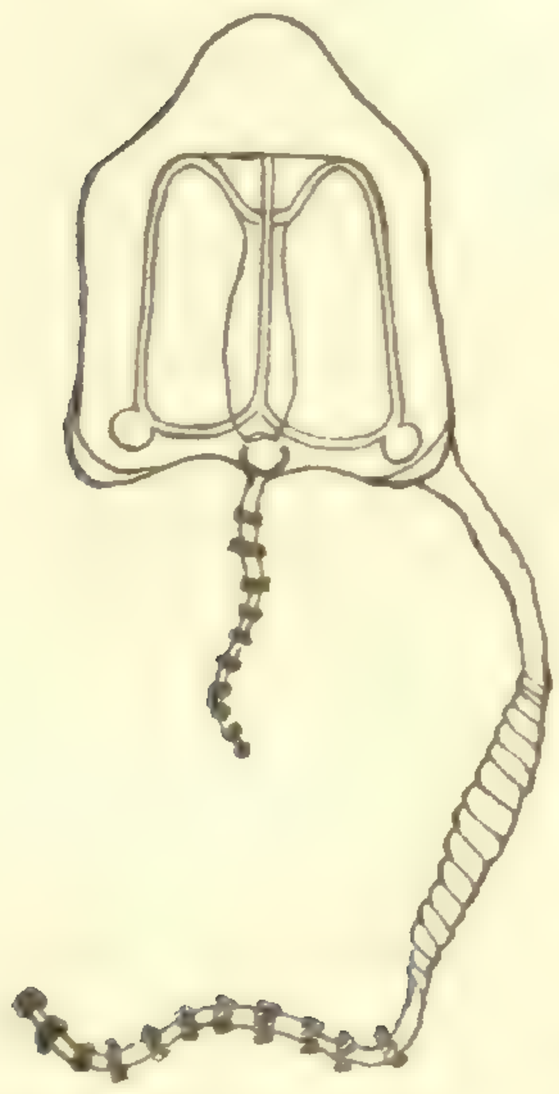

FIG. 38. — *Corymorpha pendula* Ag. (After Agassiz.)

Bell somewhat unsymmetrical, oblong with subconical apex; tentacles unequally developed, one being quite long and heavy, the others much smaller; manubrium similar to the preceding, both in form and color; bases of tentacles of pinkish color; size from five to six mm. Common along the coast, hydroids dredged from waters of Vineyard Sound, Massachusetts Bay, etc. Hydroid generation, — Corymorpha.

Hybocodon prolifer Ag. (FIG. 39).

Bell similar to preceding, but with marked asymmetry; a single marginal tentacle of large size, with very thick basal portion, from which there bud proliferously secondary medusæ, which in turn similarly bud tertiary medusæ, several generations in this way being present upon the parent medusa. In other aspects very similar to the preceding. Hydroid generation, — Hybocodon.

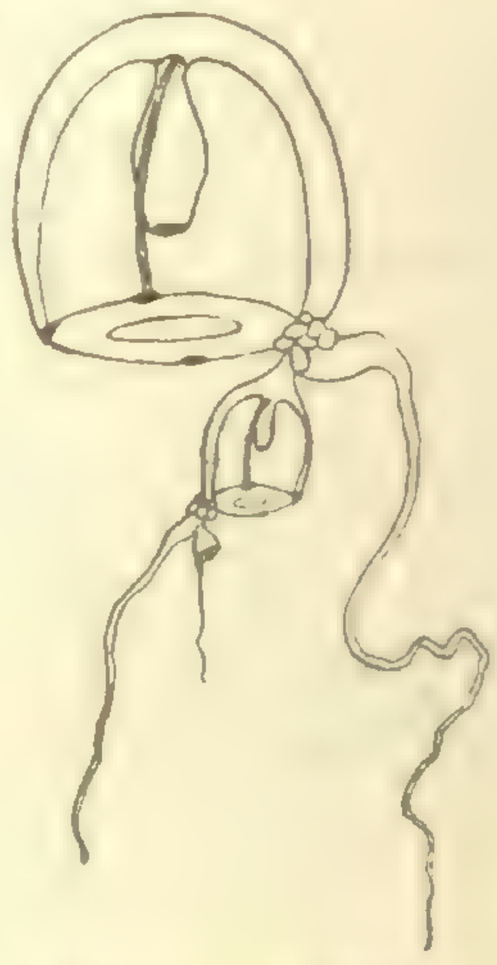

FIG. 39. — *Hybocodon prolifer* Ag.

Stomotoca apicata Ag. (FIG. 40).

Bell rather open and shallow, with an elongate conical projection at the apex: radial canals four: marginal tentacles two, which are long and slender and highly retractile: manubrium also retractile, with a four-lobed

oral margin. Color: manubrium, yellow or cream-color, base of tentacles purplish. Male often with green manubrium. Hydroid (?).

Stomotoca rugosa Mayer.

General form of the medusa similar to the preceding; apical projection sometimes long, sometimes short and blunt; size about five mm. in height by three mm. broad; two long marginal tentacles and fourteen rudimentary ones; radial canals four; velum well developed. Distinguished from *S. apicata* in part by the distinctively different color, which in this species is of a brick-red at tentacular bases and manubrium, while in the preceding (*S. apicata*) the manubrium is greenish or straw-colored in the male and dull ochre in the female, and the tentacle bases in male are purplish and in female ochre. Hydroid generation, — a Perigonimus.

Habitat: Common at Newport, R. I., and southward.

(Condensed from Mayer's description. *Bull. Mus. Comp. Zoöl.*, Vol. XXXVII, No. 1, p. 4.)

FIG. 40. — *Stomotoca apicata* Ag. (After McCrady.)

Turris vesicaria A. Ag. (FIG. 41).

Bell hemispherical, with large globular projection at its apex; marginal tentacles numerous; bases broad and with a single ocellus on each; tentacles tapering rapidly from the base and becoming delicate and filamentous; manubrium large and with four fimbriated oral lobes; gonads borne upon the base of manubrium and even extending somewhat upon the radial canals, the walls of which are notched and variously irregular, as are also the walls of the marginal canal.

(Condensed from description of A. Agassiz, *No. Am. Acalephæ*, p. 164.)

Hydroid generation, — a Turris (?).

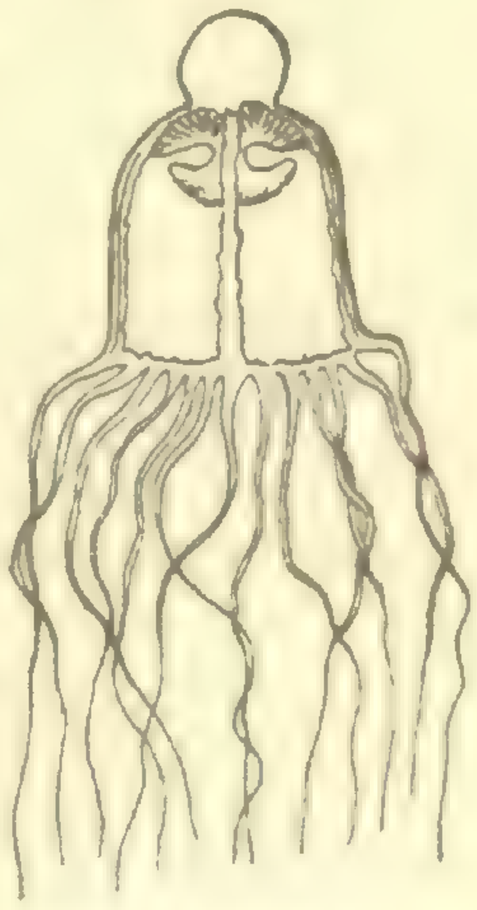

FIG. 41. — *Turris vesicaria* A. Ag. (After A. Agassiz.)

Turritopsis nutricula McCr. (FIG. 42).

Bell high-hemispherical or subspherical; radial canals four; velum broad; marginal tentacles varying from four to thirty or more, depending upon stages of maturity; a reddish ocellus at bases of tentacles; manubrium large but not

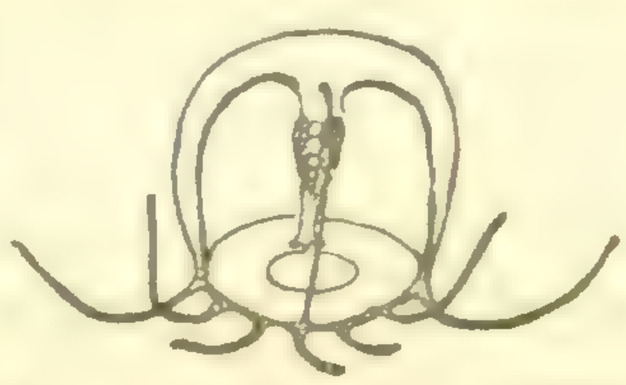

FIG. 42. — *Turritopsis nutricula* McCr. (After McCrady.)

reaching beyond the velum : gonads of reddish orange color and arranged in four masses upon the manubrium. Hydroid generation, — a Dendroclava.

Dysmorphosa fulgurans A. Ag. (FIG. 43).

Bell subhemispherical, with slight conical apical projection : radial canals four ; marginal tentacles eight, symmetrically disposed ; manubrium of medium size, its oral end provided with four rather prominent tentacles ; from the body of the manubrium secondary medusæ bud off with great profusion, their numbers at times becoming so great as to afford a splendid phosphorescence (A. Agassiz). Hydroid (?).

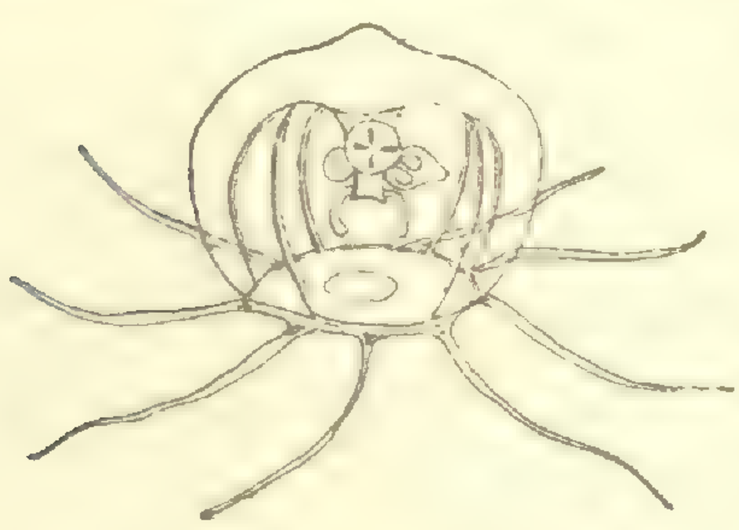

FIG. 43. — *Dysmorphosa fulgurans* A. Ag. (After A. Agassiz.)

Podocoryne carnea Sars (FIG. 44).

Medusa oval or bell-shaped or subglobular, form variable ; exumbrella surface dotted with nematocysts ; size about five mm. in height by slightly more than half as broad ; marginal tentacles eight, four radial, four *interradial*, instead of all *radial*, as stated in Part I in describing the gonosome of Podocoryne, the latter shorter ; pinkish ocelli at bases of tentacles ; manubrium of medium size, though extensible to velum, of quadrangular form, with four oral lobes tipped with nematocysts ; gonads borne on base of manubrium.

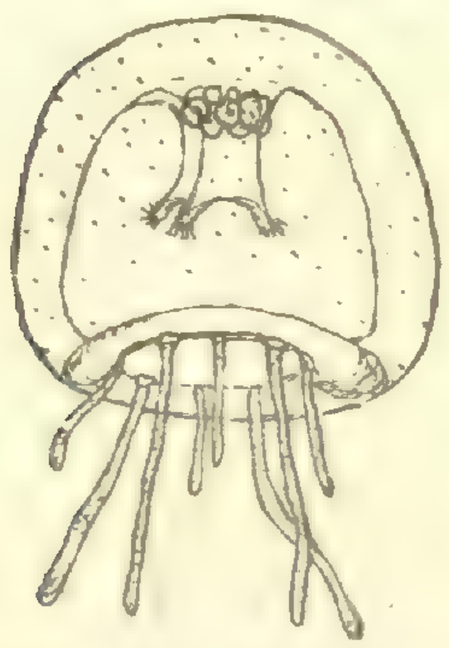

FIG. 44. — *Podocoryne carnea* Sars.

This medusa has been confused with the preceding, which has usually been designated as the product of Podocoryne. This is, however, a mistake. Podocoryne, so far as I am aware, never produces proliferous medusæ from the manubrium, as is the case with Dysmorphosa. I have often followed the direct liberation of the medusæ from the hydroid, and they have even at that time sex products well developed. Bunting has also noted the same thing. (Cf. *Journ. Morph.*, Vol. IX.)

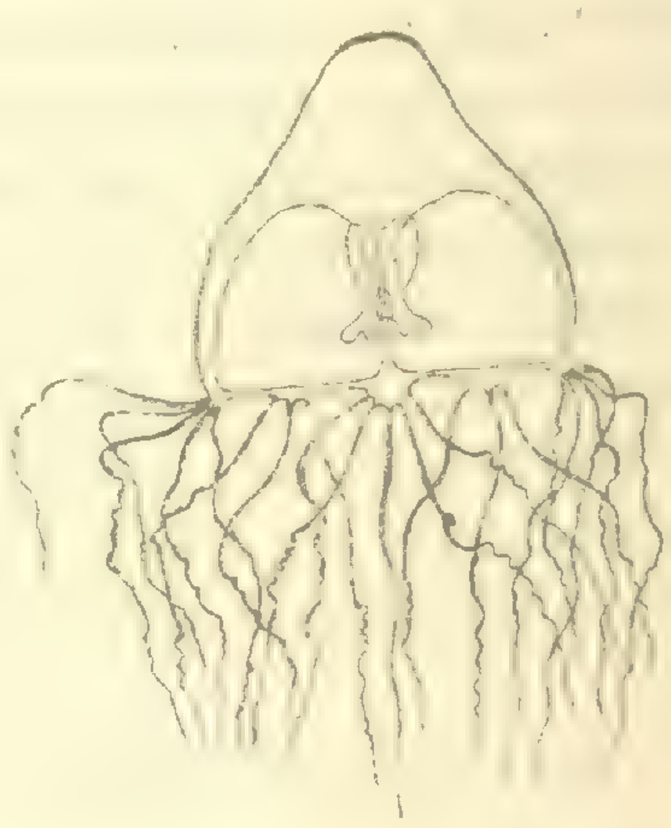

FIG. 45. — *Lizzia grata* A. Ag. (After A. Agassiz.)

Lizzia grata A. Ag. (FIG. 45).

Bell subconical. its apex obtusely rounded ; radial canals four ; marginal tentacles in eight clusters, the radial groups with five each, the interradial groups with three, in mature specimens ; young with only radial tentacles, one at each radius ; there are no ocelli ;

manubrium of medium size, with four prominent and branched oral tentacles : gonads form prominent masses on body of manubrium. Hydroid (?).

Bougainvillia (*Margelis*) *carolinensis* Ag. (Fig. 46).

Bell subspherical, wall becoming very thick over the aboral part ; radial canals four, inconspicuous; marginal tentacles in four clusters, of about ten each ; in young specimens just liberated there are but two in each group and the bell is less globular, while the oral tentacles are simple ; later these become dichotomously branched about three times ; ocelli are grouped about the base of each of the four triangular sensory bulbs. One of the commonest of our Medusæ, reaching at maturity a size of about eight mm. Color greenish or greenish-blue. Hydroid, — *Ibid.*

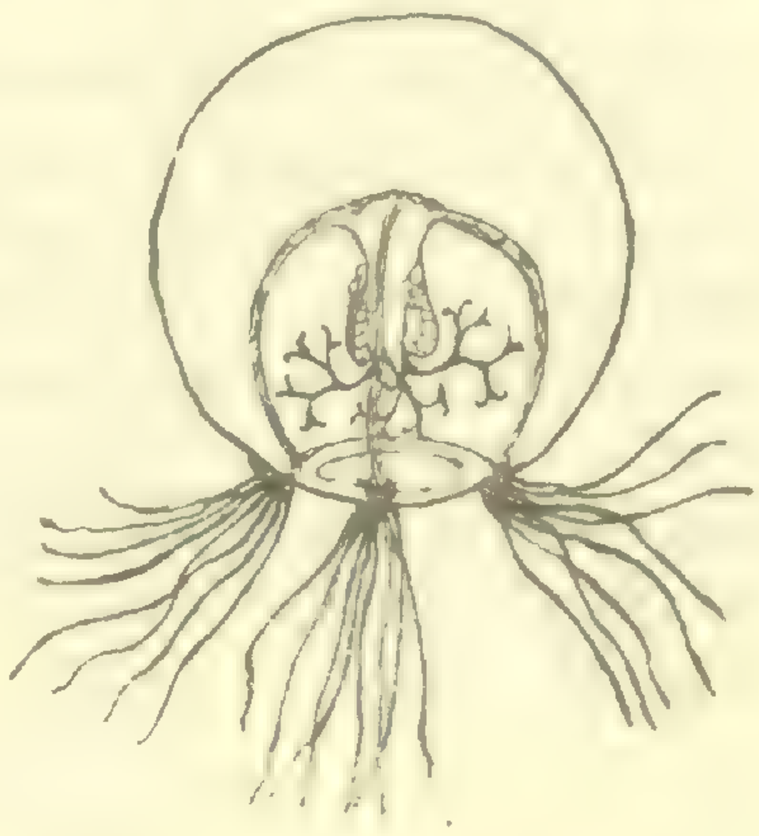

Fig. 46. — *Bougainvillia carolinensis* Ag.

Bougainvillia superciliaris Ag.

In general form and aspect very much like the preceding species, but of larger size and different shape, being somewhat obovate ; the marginal tentacles are also more numerous as well as longer, a character common also to the oral tentacles, while the manubrium is broader and shorter. Ocelli as in the former. Of yellowish color. Hydroid, — *Ibid.*

Bougainvillia gibbsii Mayer.

Very similar to the preceding, distinguished according to Mayer by the relatively greater height and smaller width, and by the short and broad manubrium, which in cross-section is cruciform. (Cf. *Bull. Mus. Comp. Zoöl.*, Vol. XXXVII, No. 1, p. 5.) Hydroid (?).

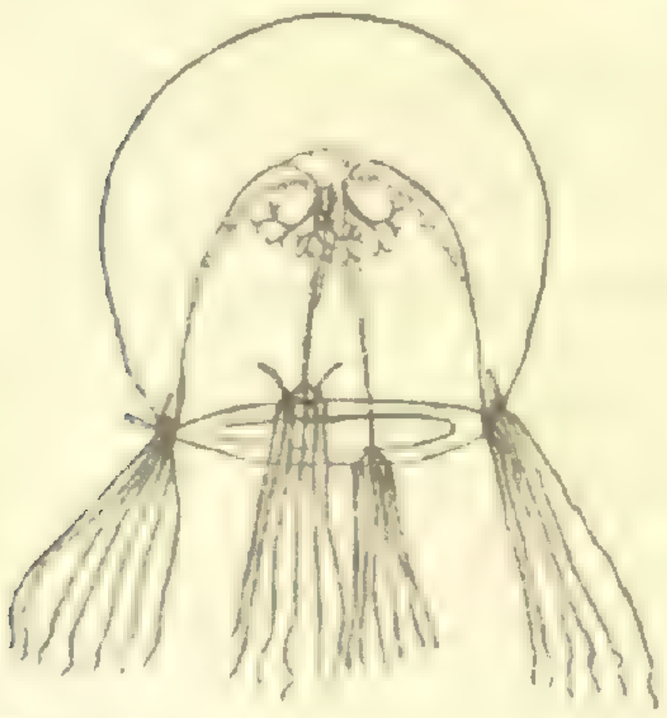

Fig. 47. — *Nemopsis bachei* Ag.

Nemopsis bachei Ag. (Fig. 47).

In general characters Nemopsis has many features in common with Bougainvillia, such as shape, mode of development, etc. The more distinctive differences are to be found in the number and character of the marginal tentacles, more particularly in the pair of erect, clavate ones which spring laterally from the tentacular bulbs, as shown in the figure. Again, the gonads present characteristic differences, arising from the basal portion of the manubrium and extending beneath the radial

canals, in some cases almost the entire length. Ocelli are present and like those in the preceding genus. In color the sensory bulbs are yellowish or orange, as are also the gonads. In size mature specimens vary from six to ten mm. Hydroid (?).

Stylactis hooperii Sigerfoos.

(*American Naturalist*, vol. xxxiii, p. 801.)

Bell globular, slightly elongate, about one mm. in long diameter; radial canals four; marginal tentacles eight, very rudimentary, symmetrically distributed about the margin; ocelli absent; manubrium large, devoid of oral tentacles or lobes; velum narrow; gonads borne in a general mass about the manubrium; genital products discharged at once on liberation of the medusa, which is quite active for a brief time following its liberation, but dies soon after discharge of eggs or sperms.

Habitat: Colony taken from shell of live snail, *Illyanassa obsoleta*. Hydroid, — *Ibid.*

Gemmaria cladophora A. Ag.

Bell hemispherical or subconical, walls rather thick, but varying in different regions, giving to the bell cavity a shape different from that of the external outline; radial canals four; marginal tentacles four, but two rudimentary, the larger abundantly provided with nematocysts, many of which are stalked; tentacular bulbs brownish, with orange pigment at bases; manubrium large, with basal conical portion separated by a sharp constriction from the oral portion, which has a flaring, quadrangular opening. Hydroid (?).

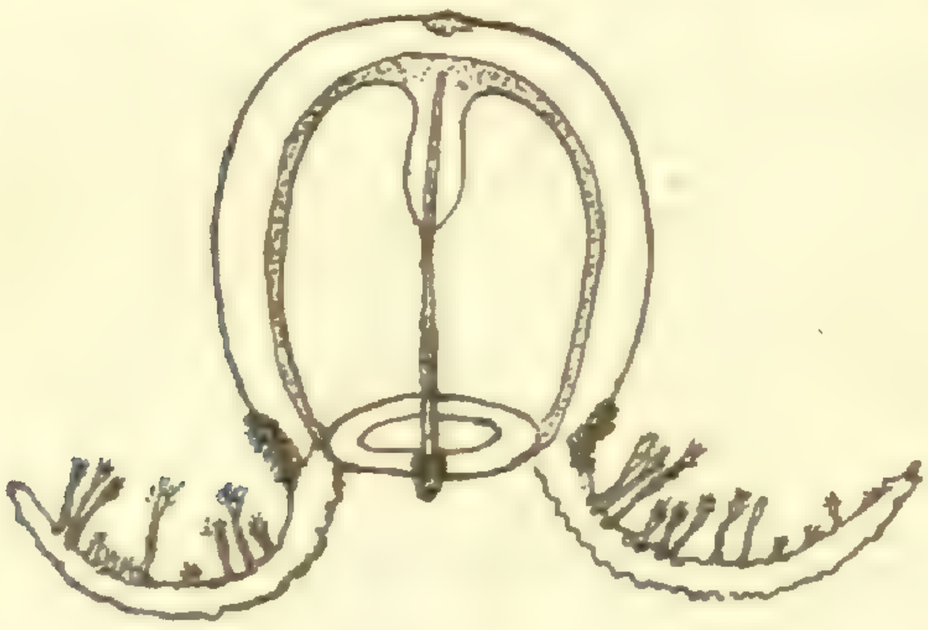

FIG. 48. — *Corynitis agassizii* McCr. (Adapted from McCrady.)

Corynitis agassizii McCr.
(FIG. 48).
(Gemmaria gemmosa McCr.)

Bell elongate-hemispherical or obovate; marginal tentacles two, thick and fringed with an abundance of stalked nematocysts and batteries scattered over the tentacles from base to tip; radial canals four, with clusters of nematocysts at their marginal termini; velum well developed; manubrium of medium size, somewhat conical in shape. Mature specimens from one to two mm. in diameter.

Habitat: Taken from shells of Mytilis, etc. Hydroid, — *Ibid.*

Willia ornata McCr. (Fig. 49).

Body of medusa bell-shaped or conical, with blunt apical projection; marginal tentacles sixteen in mature specimens, arising from the terminals of the branched radial canals; primary canals four in young specimens, which by repeated branching become sixteen, and the development of the tentacles follow the same course of development, appearing after the several divisions of the canals; manubrium rather stout and with lobed oral margins. Intermediate between each pair of tentacles an undulating line of nematocysts, "knotted cords," passes upward on the bell. Hydroid (?).

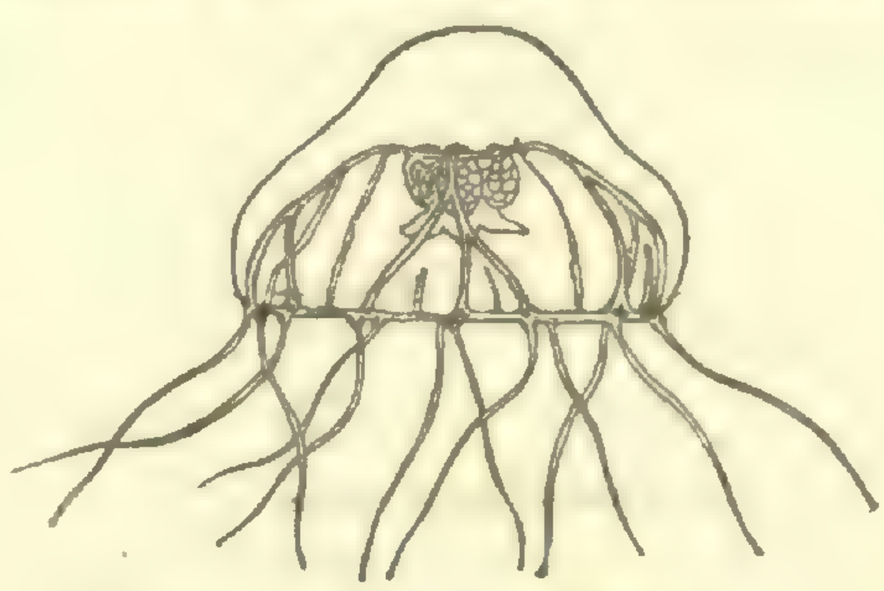

Fig. 49.— *Willia ornata* McCr. (After A. Agassiz.)

(Adapted from McCrady's description, *Proc. Elliott Soc.*, Vol. I, p. 149.)

LEPTOMEDUSÆ.

As compared with the Anthomedusæ, the Leptomedusæ are generally flatter and more disk-like; the velum is usually smaller, and the texture of the bell is softer. Ocelli may or may not be present; otocysts may or may not be present; the gonads are borne upon the radial canals.

SYNOPSIS OF FAMILIES.

I. Thaumantidæ. Ocelli present, but no otocysts; radial canals four or eight (rarely more), always simple and unbranched.

II. Cannotidæ. Without either otocysts or ocelli; radial canals four or six, which are branched or pinnate.

III. Eucopidæ. Otocysts always present, eight or more; ocelli usually absent; radial canals usually four, simple and unbranched.

IV. Æquoridæ. Otocysts always present; radial canals numerous, at least eight, often a hundred or more, usually simple, rarely branched.

Key to Genera.

Thaumantidæ.

A. Radial canals four; marginal tentacles numerous, and with basal cirri . . . . . Lafœa

B. Radial canals eight; marginal tentacles numerous, but without basal cirri . . . . . Melicertum

CANNOTIDÆ.

Radial canals four, each with lateral, sometimes pinnate, branches which end blindly. A single genus within the range of this synopsis so far as known to the writer . . . . . Ptychogena

EUCOPIDÆ.

A. Marginal tentacles four, sometimes with lateral basal cirri.

1. Manubrium very long, extending much beyond velum . Eutima
2. Manubrium short, tentacles with basal cirri . . . . Eucheilota
3. Manubrium short, tentacles devoid of basal cirri . . Clytia (Juv.)

B. Marginal tentacles sixteen or more.

1. Manubrium long, bell hemispherical . . . . . Tima
2. Manubrium short, bell disk-like, otocysts on bases of tentacles Obelia
3. Manubrium short, mouth plain, bell hemispherical, otocysts between bases of tentacles . . . . . Clytia
4. Manubrium short and with fimbriated oral lobes . . . Tiaropsis
   (*a*) With 16 tentacles . . . . . Epenthesis
5. Manubrium short and with oral lobes plain.
   (*b*) With more than 16 tentacles . . . . . Oceania

ÆQUORIDÆ.

A. Radial canals eight or more, often lobed or divided at their bases Halopsis

B. Radial canals numerous, twelve to one hundred or more.

1. Manubrium very short, often indistinguishable, and with crenulated oral margin . . . . . Rhegmatodes
2. Manubrium well developed, oral margin lobed but plain Æquorea
3. Manubrium large and with complex and fimbriated oral lobes Zygodactyla

Lafœa calcarata A. Ag. (FIG. 50).

Bell broad, somewhat conical or dome-shaped, marginal tentacles numerous, somewhat swollen at base, long and filamentous, and interspersed with tentacular spurs, clubs, and cirri; gonads suspended in convoluted masses beneath radial canals, of milky or yellowish color; manubrium short and with convoluted oral lobes. When first liberated, the medusa is small and with only two tentacles, others appearing with growth; ocelli are located upon the bases of the tentacles. Size about 20 mm. in diameter. Hydroid, — *Ibid.*

Melicertum campanula Esch.

Medusa bell-shaped or subconical; marginal tentacles very numerous, long, and filamentous, but devoid of basal cirri; radial canals eight at maturity, four in young specimens; gonads suspended in sinuous folds beneath radial canals; manubrium much as in preceding, with oral lobes sinuously convoluted; color of bell light ochre, tentacles and gonads much darker. Reported from Greenland, Grand Manan, Nahant, etc., A. Ag. Newport Harbor, May Mayer. Hydroid (?).

Ptychogena lactea A. Ag.

Bell the small segment of a sphere, walls rather thick; radial canals four, but with sides variously notched and in the medial portions increasing to extended lateral diverticula; tentacles very numerous and filamentous; gonads variously folded and disposed beneath radial canals; devoid of either ocelli or otocysts. According to A. Agassiz (p. 137, *N. A. Acalephæ*), from whose account both this and the preceding description are condensed, this medusa lives chiefly at considerable depths, and exposure to light or increased temperature rapidly disintegrates it. Hydroid (?).

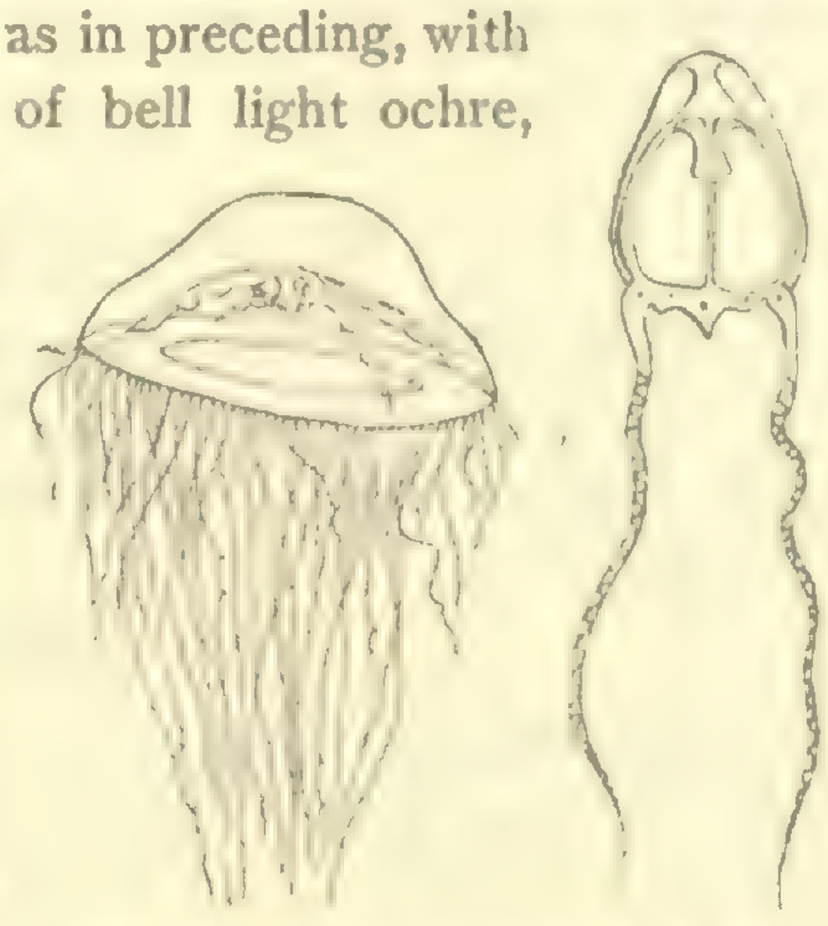

FIG. 50.—*Lafœa calcarata* A. Ag.
a, a young medusa of same.
(After A. Agassiz.)

Eutima mira McCr. (FIG. 51).

Medusa broadly bell-shaped, tending to conical; marginal tentacles four, long and tapering from an enlarged base; numerous minute tentacular processes distributed about the margin; otocysts eight, symmetrically disposed; manubrium very long, extending far beyond the velum, and terminating in an everted, somewhat frilled margin; gonads disposed beneath radial canals. Hydroid (?).

FIG. 51.—*Eutima mira* McCr.
(After McCrady.)

Eutima limpida A. Ag.

Medusa much as in preceding species, but with both manubrium and tentacles shorter, the latter without the basal swellings of the former and the oral margin less frilled; broad diameter one to two inches, height much less; otocysts large and with numerous lithocysts. Hydroid (?).

Eucheilota ventricularis McCr.

Bell of medusa hemispherical; radial canals four, wide and with the gonads extending their entire length; marginal tentacles twelve to twenty in mature specimens, only four at liberation of medusa; manubrium short, tubular, of yellowish color with reddish central portion; gonads similar in color; otocysts eight, with lithocysts arranged in an arc. Hydroid (?).

Eu. duodecimalis A. Ag. (FIG. 52).

Medusa similar to preceding species, but with twelve otocysts and with only four long tentacles, each with a pair of lateral cirri at the base; gonads borne on distal half of radial canals. Hydroid (?).

Clytia bicophora Ag. (FIG. 53).

Medusa variable in appearance with age; when first liberated, the bell is rather globular, later becoming flattened and finally at maturity being hemispherical; diameter about five mm.; radial canals four, beneath which the gonads, which are dull brown in color, extend from base of the short manubrium about to their middle portion; marginal tentacles eight, with intermediate tentacular buds; otocysts eight. Hydroid, — *Ibid.*

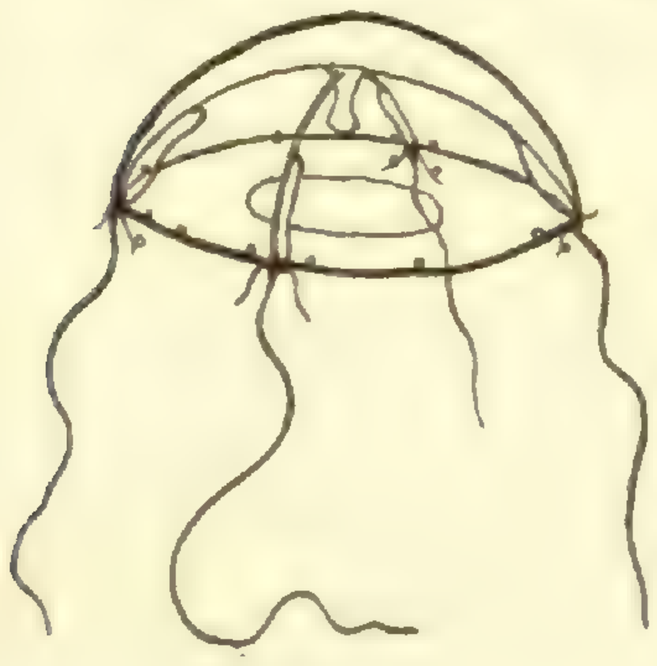

FIG. 52.

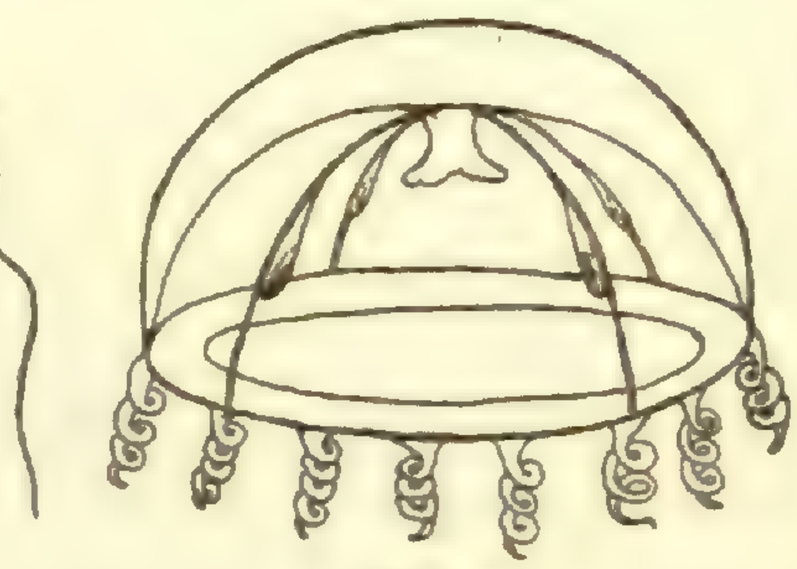

FIG. 53.

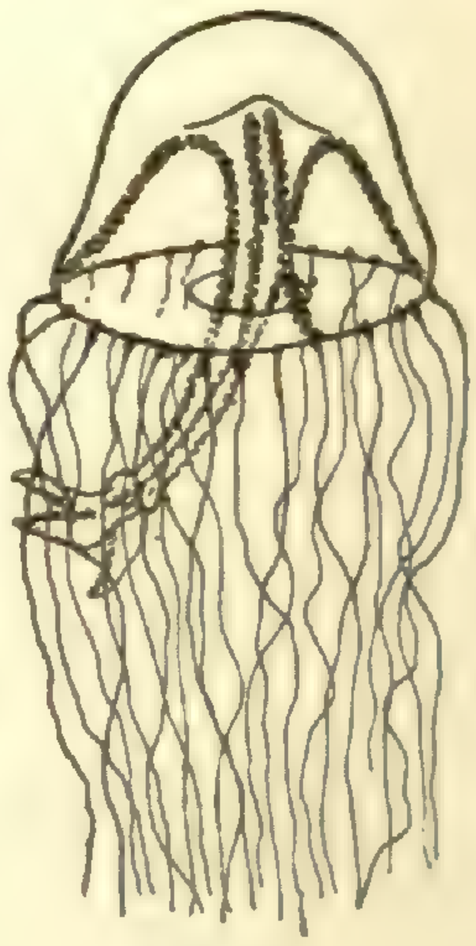

FIG. 54.

FIG. 52. — *Eucheilota duodecimalis* A. Ag. (After A. Agassiz.)
FIG. 53. — *Clytia bicophora* Ag. (After A. Agassiz.)
FIG. 54. — *Tima formosa* Ag. (After A. Agassiz.)

C. nolliformis McCr.

Medusa much as in preceding; marginal tentacles four in young specimens, increasing in number with age; otocysts eight, between bases of tentacles; manubrium short and with four oral lobes. Hydroid (?).

Tima formosa Ag. (FIG. 54).

Medusa bell-shaped or elongate hemispherical; marginal tentacles numerous, long, filamentous, and with bulbous bases; radial canals four, and with convoluted, pouch-like gonads extending their entire length;

otocysts symmetrically distributed about the margin, between the tentacular bases; manubrium large and long, extending beyond the velum, and terminating in a series of fringed, lip-like lobes. Hydroid (?).

Obelia Per. & Les.

Generic characters: Medusa flat and disk-like; marginal tentacles numerous, projecting slightly inward at the base; otocysts eight, borne on base of tentacles at the inner portion; manubrium short and somewhat quadrate. Medusæ often swimming with everted bell.

O. geniculata Linn. (Fig. 55).

Medusa flat; marginal tentacles twenty-four at liberation; gonads as oval bodies beneath middle of radial canals. Hydroid, — *Ibid.*

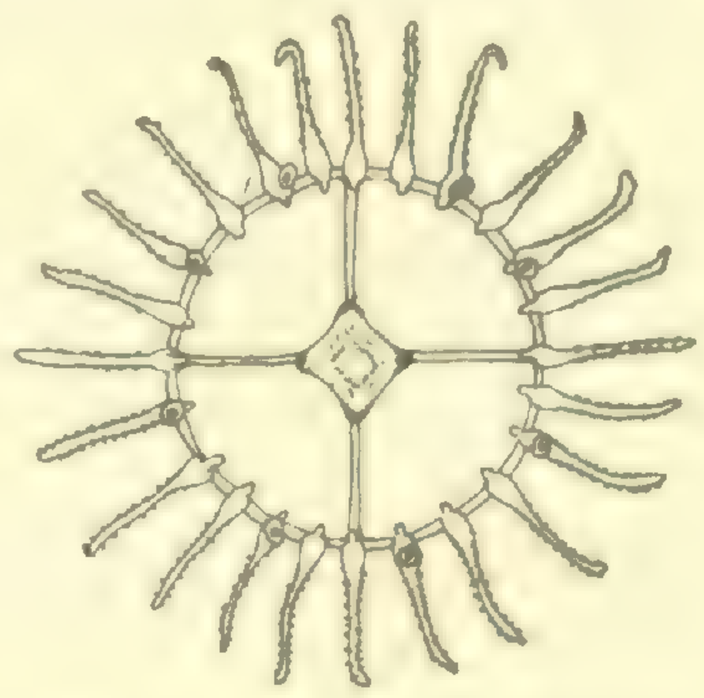

Fig. 55. — *Obelia geniculata* Linn.

O. longissima Pallas.

Very similar to preceding. Hydroid, — *Ibid.*

O. flabellata Hincks.

(Eucope polygena A. Ag.)

In general aspects indistinguishable from the preceding species. Hydroid, — *Ibid.*

O. gelatinosa Pallas.

(Laomedia gigantea A. Ag.)

In general feature similar to former, but with only sixteen tentacles at liberation. Hydroid, — *Ibid.*

O. dichotoma Linn.

Indistinguishable from *O. gelatinosa*. Hydroid, — *Ibid.*

O. commisuralis McCr.

In general features very like the preceding species, but with tentacles somewhat more slender and elongated. Hydroid, — *Ibid.*

Tiaropsis diademata Ag. (Fig. 56).

Medusa ovoid when young, becoming hemispherical at maturity: radial canals four; marginal tentacles very numerous, the larger with swollen bulbous bases: otocysts eight, situated between bases of tentacles and with otoliths in form of arc: gonads extending beneath radial canals; manubrium short, with terminal lobes complexly fimbriated. Hydroid (?).

Oceania languida A. Ag. (FIG. 57).

Medusa ovoid when set free, becoming hemispherical at maturity; radial canals four; marginal tentacles numerous in adult specimens; otocysts eight, situated near bases of tentacles in young specimens, but becoming numerous as medusæ mature, increasing in number according to A. Agassiz by subdivision of the primary otocysts; gonads of brownish or pink or green color, and borne on distal portions of canals. Hydroid (?).

Oceania carolinæ Mayer.

Bell less than a hemisphere, about 14 mm. in diameter; marginal tentacles sixteen, with large hollow basal bulbs, also numerous rudimentary tentacular bulbs interspersed; otocysts 64, symmetrically disposed; manubrium flask-shaped, and with four simple oral lobes; gonads borne on distal portions of radial canals; tentacular bulbs bright yellow-green. Charleston Harbor.

(Condensed from Mayer's description, *Bull. Mus. Comp. Zoöl.*, Vol. XXXVII, No. 1.)

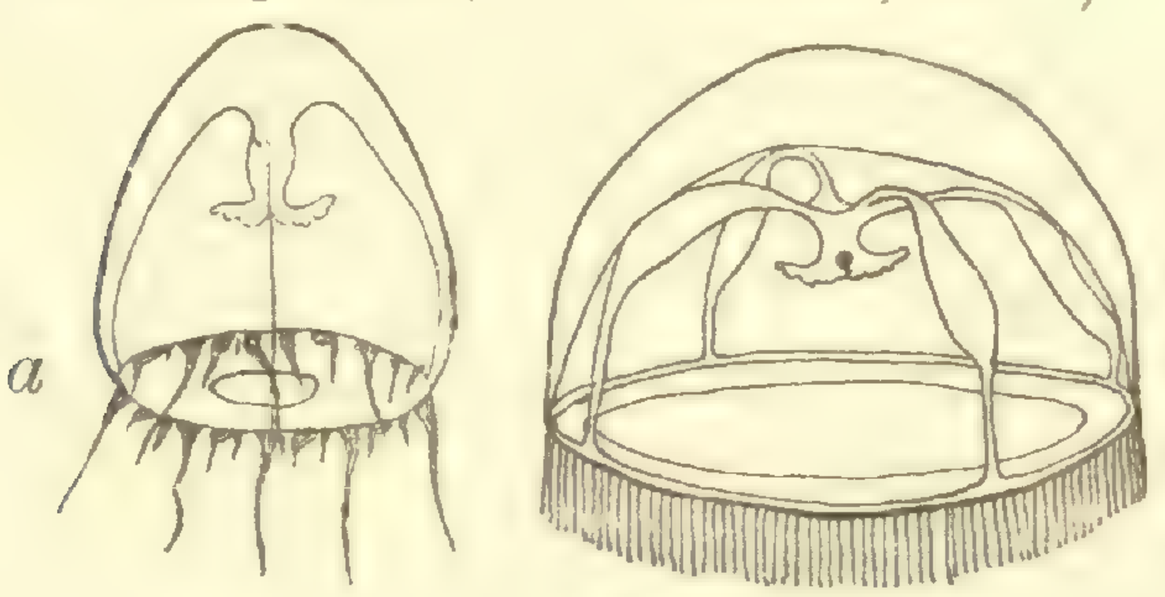

FIG. 56.

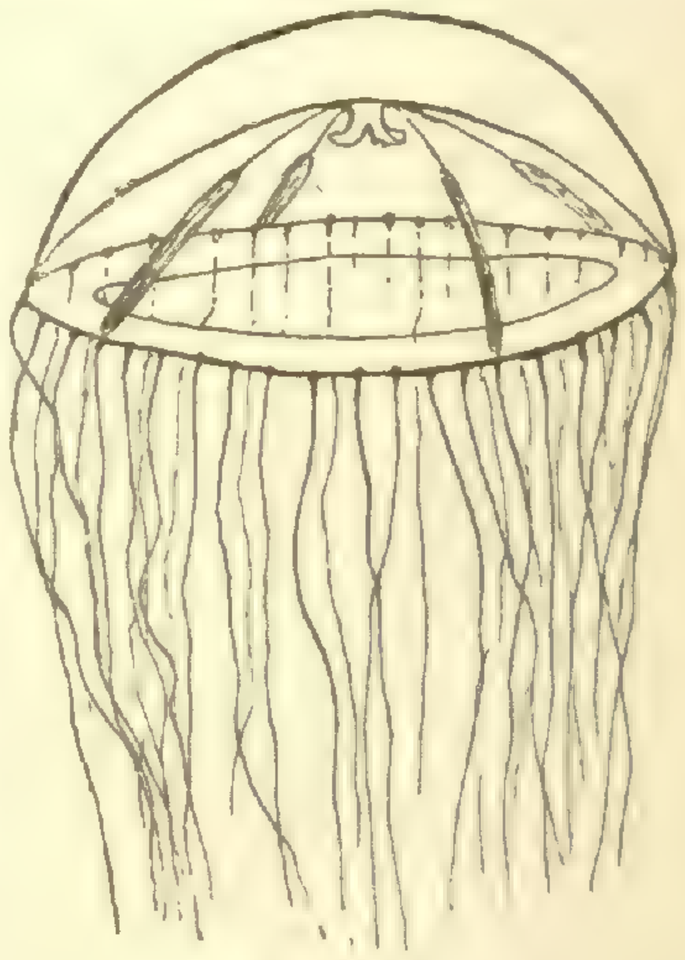

FIG. 57.

FIG. 56. — *Tiaropsis diademata* Ag. (After A. Agassiz.) *a*, young medusa of same.
FIG. 57. — *Oceania languida* A. Ag. (After A. Agassiz.)

O. singularis Mayer.

Bell about two mm. in diameter, with lens-shaped apical projection; marginal tentacles 16, with hollow basal bulbs, and with 16 rudimentary tentacles symmetrically disposed; otocysts 32; gonads borne on upper portion of radial canals; colors of tentacular bulbs and radial canals in region of gonads turquoise-green. Newport Harbor, R. I.

(Condensed from Mayer's description; cf. *op. cit.*)

Epenthesis foleata McCr.

(Oceania foleata Ag.)

Medusa with low, subhemispherical bell, about five mm. in diameter: marginal tentacles sixteen, rather slender and with well-developed basal

bulbs; otocysts alternating with bases of tentacles; manubrium short and with four recurved oral lobes; gonads borne upon lower portions of canals. Manubrium, gonads, and sensory bulbs light greenish in color. Hydroid (?).

Halopsis ocellata A. Ag.

Bell low and flat in mature specimens, though somewhat hemispherical in young medusæ; radial canals twelve to twenty in mature specimens; marginal tentacles very numerous and highly contractile, and with interspersed cirri; otocysts numerous and with numerous otoliths arranged in double rows; manubrium short, with four recurved sinuous oral lobes. Hydroid (?).

(Condensed from description of A. Agassiz, *N. A. Acalephæ*, p. 99.)

H. cruciata A. Ag.

Under this name A. Agassiz briefly describes a medusa having but four radial canals, a hemispherical bell, comparatively few tentacles, and otherwise so unlike the preceding as to render its generic, if not family, affinities wholly distinct. Not having access to specimens, it is merely listed without further comment. Hydroid (?).

Rhegmatodes tenuis A. Ag. (Fig. 58).

Bell low, with rounded aboral surface and with margins distinctly incurved, radial canals numerous, varying from twenty to forty or more in specimens examined; canals usually simple, but with many variations exhibiting connecting branches and anastomoses; marginal tentacles numerous, rather long and filiform, tapering rapidly from a somewhat broad base, above which is a tubular spur-like flap; tentacles, like the radial canals, increase with age, the larger extending from the termini of the canals, while intermediate are smaller ones with still smaller intermediate tentacular rudiments; gonads suspended in double rows along the surface of the canals; manubrium extremely short, often indistinguishable from the very shallow gastric pouch, and with its oral margin delicately crenulated; otocysts numerous.

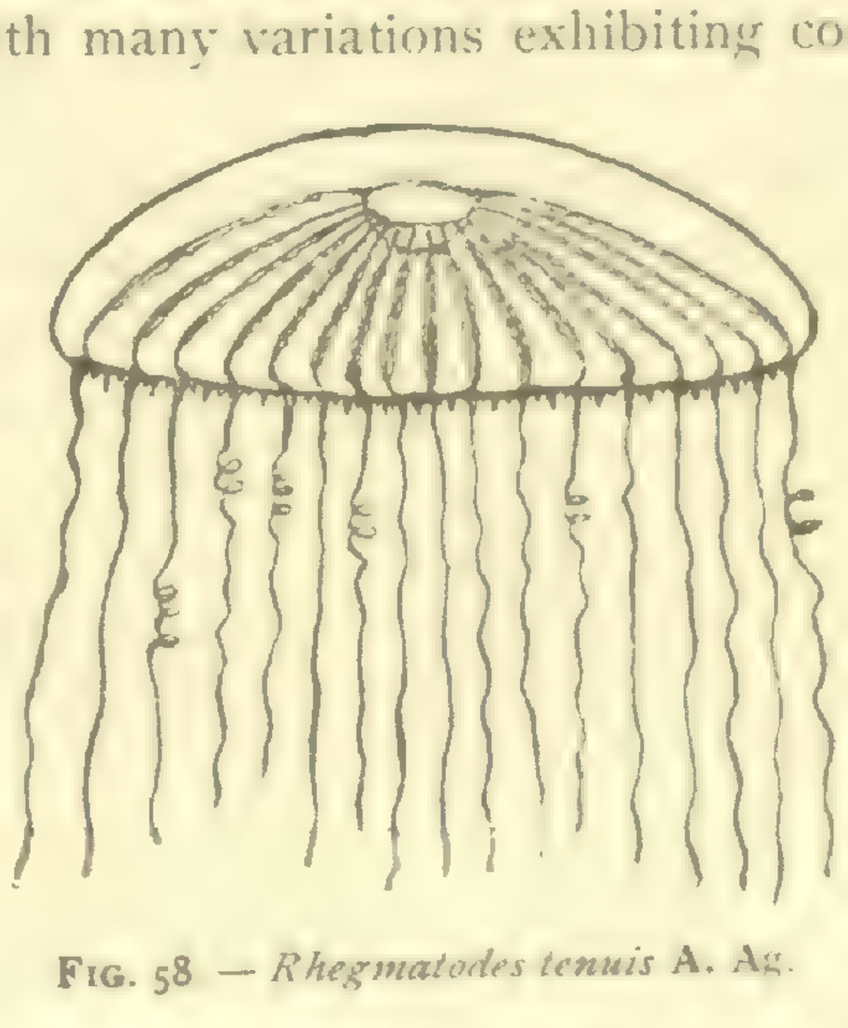

Fig. 58 — *Rhegmatodes tenuis* A. Ag.

In habit these medusæ are rather sluggish, swimming or floating near the surface and rarely exerting more than two or three pulsations of the bell or small velum in succession. Hydroid (?).

R. floridanus Ag.

Very similar to the preceding, though smaller, and of southern range.

Æquorea albida A. Ag.

Bell subhemispherical, tending to conical above; radial canals very numerous, and with two or three marginal tentacles borne between each; otocysts also numerous, spherical, and containing several small otoliths; above the base of each of the larger tentacles is a tentacular spur, similar to those of Rhegmatodes; manubrium short and with simple oral lobes. In size mature specimens vary from one to two inches in diameter. Not uncommon in the vicinity of Buzzards Bay during later summer. Hydroid (?).

Zygodactyla grœnlandica Ag.

This is one of the largest of the Hydromedusæ, sometimes measuring twelve to fifteen inches in diameter; bell rather low and flat; radial canals very numerous; marginal tentacles long and very contractile, and several between the terminals of the radial canals; above the bases of the tentacles are conical spurs quite similar to those of the two preceding genera; manubrium large and elongated, extending beyond the velum when fully expanded, and with densely frilled or fimbriated oral lobes; gonads borne along the lines of the canals as in the former genera. Habitat from Greenland, Maine, Massachusetts, southward. Hydroid (?).

TRACHOMEDUSÆ.

The synoptic characters of this order have already been given. Of representatives there are comparatively few which come within the range of the present synopsis. No details of arrangement under appropriate families will therefore be undertaken in this connection, but the genera and species will be noted so far as known, and some placed provisionally under the order, of whose exact affinities there is doubt. Hydroid generation suppressed.

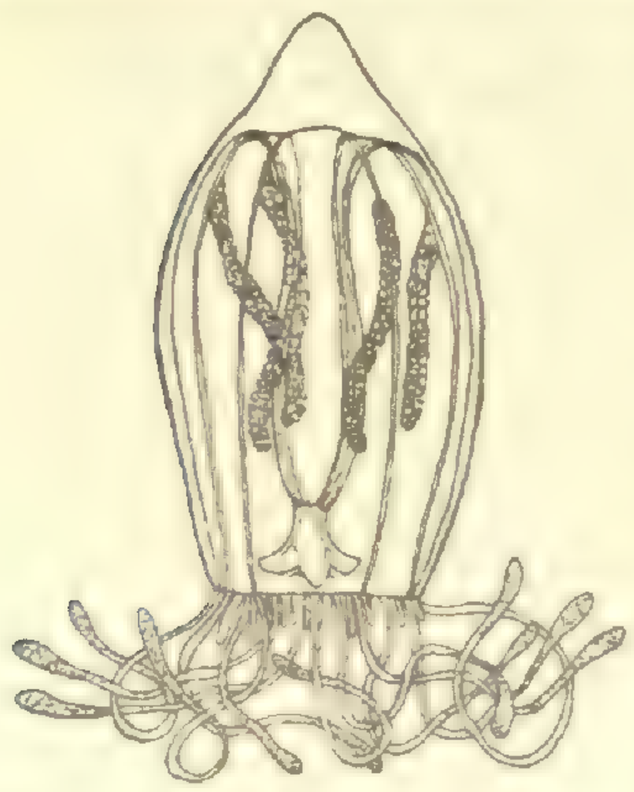

FIG. 59.—*Trachynema digitale* A. Ag. (After A. Agassiz.)

Trachynema digitale A. Ag. (FIG. 59).

Medusa elongate bell-shaped, the apex rather sharply conical; radial canals eight, rather wide; tentacles numerous and somewhat fragile; otocysts four, rather large, and with colored otoliths; gonads eight, finger-like and suspended from the upper portions of the radial canals. Size of

mature specimens about one inch in long diameter and about half as broad. Reported from Baffins Bay, Massachusetts Bay, Nahant, A. Ag.: Newport Harbor, April, Mayer.

Gonionemus murbachii Mayer. (Fig. 60).

Medusa with low hemispherical bell when in repose, but subconical when in active motion and contraction; radial canals four, prominent and with line of brownish pigment over their course; marginal tentacles numerous, varying from sixteen to eighty or more, rather long but capable of being greatly contracted; rather prominent basal bulbs of brownish color tinged with pale green; a characteristic of the tentacles is the presence of adhesive or suctorial pads a short distance from the tips, beyond which they

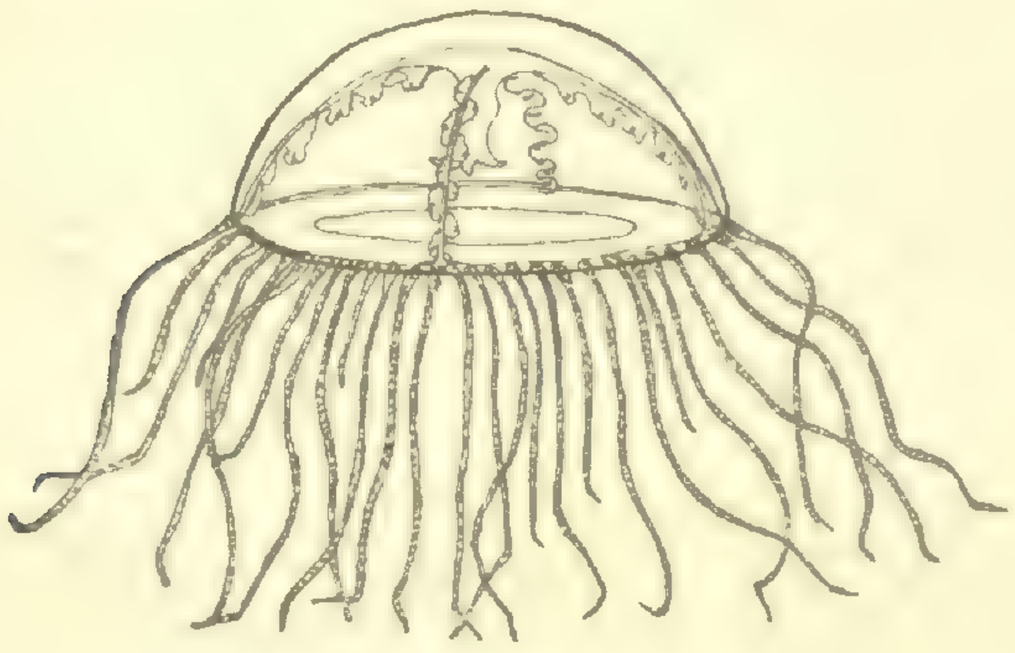

Fig. 60

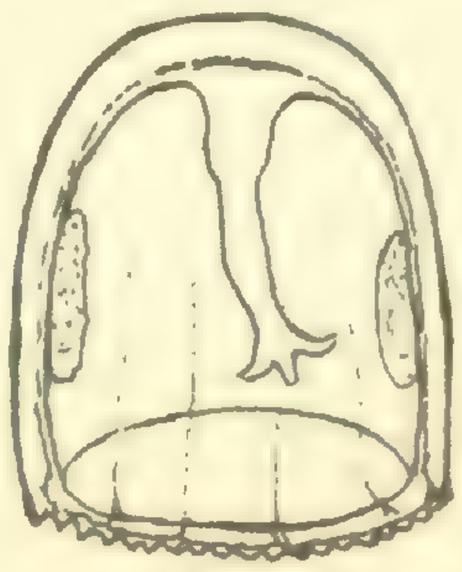

Fig. 61.

Fig. 60. — *Gonionemus murbachii* Mayer.
Fig. 61. — *Persa incolorata* McCr. (Modified from McCrady.)

often are bent at a sharp angle; manubrium of moderate size, quadrate in form and with prominent frilled oral lobes; gonads suspended in sinuous folds beneath the radial canals; otocysts present in variable numbers and disposed between the bases of the tentacles.

Persa incolorata McCr. (Fig. 61).

Bell thimble-shaped, walls thin, the entire medusa colorless except the pale yellowish gonads, which are oval and attached to the walls of two opposite radial canals, of which there are eight, only two of which are very definite; margin of the bell devoid of tentacles, but nodulated by the presence of batteries of nematocysts.

(Condensed from McCrady's account, *Gymn. Charl. Harb.*, p. 104.)

Liriope scutigera McCr.

Described by McCrady (*op. cit.*, p. 106) from Charleston Harbor, and noted by Mayer from Florida (*Bull. Mus. Comp. Zoöl.*, Vol. XXXVII, No. 2, p. 64). Also from Newport Harbor, by latter observer.

NARCOMEDUSÆ.

No representatives of this order have been taken by the present writer along our northeastern coast, and but few have been even reported from within the range of this synopsis. The following records and references may therefore suffice:

Cunoctantha octonaria McCr. Charleston Harbor. *Proc. Elliott Soc.*, Vol. I.

Cunoctantha incisa Mayer. Tortugas. *Bull. Mus. Comp. Zoöl.*, Vol. XXXVII, No. 2, p. 66.

Æginella dissonema Hæck. Tortugas. *Op. cit.*, p. 66.

SIPHONOPHORA.

Of Siphonophora recorded from northeastern Atlantic waters, by far the larger number are products of the Gulf Stream, very few, if any, being indigenous faunal elements. Those more familiar and of commoner record may be grouped under the following sections:

A. Disconectæ. Siphonophora with discoidal pneumatophore, but devoid of nectophores or bracts.

1. *Velella mutica* Bosc. Pneumatophore an elliptical or oblong disk, usually with an oblique vertical crest, and with the several zooids attached to the lower surface. Common in subtropical regions and in Gulf Stream, upon the latter of which they are occasionally borne northward to the New England coast.
2. *Porpita linnæana* Less. Pneumatophore a circular disk, but without a vertical crest. Otherwise similar to former and of similar habits and distribution.

B. Calcyonectæ. Siphonophora without pneumatophore, but with one or more nectophores.

1. *Diphyes pusilla* McCr. Polygastric, with two nectophores at the apex of a long tubular trunk.
2. *D. formosa* Fewk. Cf. *Report on Medusæ of Gulf Stream Region.* Commissioner of Fish and Fisheries, 1884, p. 963.
3. *D. bipartita* Costa. Reported by Mayer (*Bull. Mus. Comp. Zoöl.*, Vol. XXXVII, p. 74) from Newport, R. I.
4. *Agalmopsis carum* A., Ag.

   Nanomia cara A. Ag. Polygastric, with long tubular trunk and with numerous siphons and bracts.
5. *Agalma okenii* Esch.
6. *Spheronectes gracilis* Haeck. Reported by Fewkes from Newport, R. I. (*Bull. Mus. Comp. Zoöl.*, Vol. VIII, p. 166.)
7. *Gleba hyppopus* Forsk. Reported by Fewkes off Marthas Vineyard. (*Rept. U. S. Comm. Fish and Fisheries*, 1884, p. 963.)

C. CYSTONECTÆ. With large vesicular pneumatophore only, no nectophores or bracts.

Physalia pelagica Bosc. Common along the coast, occasionally taken at the Bay of Fundy. The well-known Portuguese-man-of-war. One of the most conspicuous of the siphonophores, and with long graceful tentacles which are loaded with batteries of nematocysts of highly venomous character.

In the foregoing synopsis only incidental notice has been made of synonomy, any details on this line being incompatible with the purpose and limits of the paper.

It is a pleasure to acknowledge in this connection my obligations to Dr. Alfred G. Mayer, of the Brooklyn Institute, who has kindly reviewed the manuscript of Part III of this synopsis, and offered suggestions, and from whose various recent papers on Medusæ I have been able to extend the list of species in several cases.

I desire also to acknowledge the services of my son George, who has copied most of the figures and has under my direction drawn most of those made directly from nature.

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CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF SYRACUSE UNIVERSITY, February, 1901.

REVIEWS OF RECENT LITERATURE.

ZOÖLOGY.

An Anatomy of the Cat. — From the standpoint of teaching anatomy to the beginner, few animals have received more attention than the cat, and the number of easily accessible books dealing with the structure of this animal is already large. The preparation of a new volume as a competitor in this field is hazardous, to say the least, and the present venture seems all the more so because its authors, Reighard and Jennings,[1] do not propose to treat the subject in any novel way, but content themselves with the simple descriptive methods of the older anatomists.

The text embodies a well-arranged systematic description of the organs of the cat. The terminology is for the most part a judicious compromise between the various recent attempts at a revised nomenclature and the older systems. Its innovations are based chiefly on greater convenience in the use of terms, a principle which, though often ignored, eventually makes itself felt in the growth of all nomenclatures. The orthography is said to follow the best English usage, in which case there should have been no final *e* in "foramen of Monroe."

The anatomical descriptions impress the reader as having been taken directly from the specimen, and, as a rule, show none of the forced character that is so often seen in Mivart's account, where at times human anatomy seems to be directly transferred to the cat. The description of the divisions of the body cavity, however, is distinctly misleading. The reader is told that this cavity is divided by the diaphragm into two parts, an abdominal cavity and a thoracic cavity, and the latter is described in some detail. The thorax of a cat, however, does not contain a single large cavity but three such, one for the heart and one for each lung, and it is only after the scalpel of the student has been at work some time that such a cavity as that described can be said to exist. The impropriety of including such openings in the description of the anatomy of an animal must

[1] Reighard, J., and Jennings, H. S. *Anatomy of the Cat.* Henry Holt & Co., 1901. xx + 498 pp., 173 figures.

be obvious, and its only excuse is the bad example set by human anatomists in this respect. Not only are the cavities of the thorax thus unnaturally united, but the abdominal cavity, really one, narrowly escapes being divided in two, a condition which the authors, however, finally imply to be contrary to fact.

The text is illustrated by one hundred and seventy-three original figures, many of which, particularly the drawings of muscles, are models of clearness and accuracy. Some, however, especially those on the brain, lack firmness, and a few, such as Fig. 42, are so shaded that more or less of the lettering can be discovered only by elimination.

The descriptive portion of the work is followed by some forty pages of practical directions which give all that is needed for so simple a subject as the dissection of the cat, and the volume is concluded by an index of nearly three thousand entries.

Although the book is in a well-worked field, it certainly occupies a unique position, for none of its predecessors can be described as accurate, complete, and compact. These qualities will without doubt place it first among English guides to the anatomy of the cat.

P.

Two Recent Papers on the Lampreys. — In the *Fourth Annual Report of the Commissioners of Fisheries, Game, and Forests*, of New York, Professor H. A. Surface of Pennsylvania State College has a very interesting study of the lampreys of New York from the economic standpoint. He shows that the lampreys rank first in the rivers of New York as enemies of other fishes, yet not one word had hitherto been written as to any method of reducing their numbers.

Professor Surface gives a detailed account of the four lampreys found in New York, their habits, their enemies, and the species of fish on which they attach themselves, rasping off the flesh until the fish dies. The spawning habits are treated with especial care, and the fact that all die after once spawning is apparently well established.

Experiments with weirs of wire and with hand nets show what large numbers of lampreys could be destroyed in the spawning season with little expense. In the interest of other fishes, this should be done in streams and lakes which lampreys infest.

Professor Surface's paper is illustrated by numerous photographs of scenery, and of the spawning lampreys, as also of the catfishes and other fishes destroyed by them. As a practical study in economic zoölogy, this work is to be highly commended.

In the *Journal of the College of Science*, in the Imperial University of Tokyo, Dr. S. Hatta of the College of Peers has an important memoir on the development of "Pronephros and Segmental Duct in the Lamprey." It is a worthy member of the series of admirable papers setting forth the original investigations of the students and associates of Professors Mitsukuri, Watase, and Iijima — one of the most hopeful phases of the development of New Japan.

D. S. J.

Notes. — The anatomy of the wings of the thrushes belonging to the genus Micropus has been very fully worked out by Buri (*Jena Zeitschr.*, Bd. XXXIII, pp. 361–610). The account includes a full description of the brachial plexus and of the muscles of the wing, and is based on a broad comparative study of the subject. Unfortunately the general results are meagre and pertain chiefly to minor questions in the taxonomy of this group of birds. As an illustrated record of the comparative anatomy of the parts investigated, Buri's contribution is a praiseworthy effort.

The number of ants in a hill has been variously estimated. Forel made an indirect calculation for a hill of medium size of *Formica pratensis* and arrived at the conclusion that it contained 114,000 ants. The largest hills he thought might contain as many as 500,000. In these conclusions he was supported by Lubbock. Yung (*Archives Zoöl. Expérim. et Générale*, 3 Sér, Tome VII, pp. xxxiii–xxxv, 1900), however, has made actual counts of all the inhabitants in several isolated hills of *Formica rufa*. He has found the numbers to vary between 19,933 and 93,694 and not to be proportional to the size of the hill. He believes that the previous estimates have been exaggerated.

The New York State Entomological Field Station, which held its first session at Saranac Inn last summer, will remove to Ithaca for the coming season. Professor James G. Needham of Lake Forest University will continue in charge of the work. The report of the first session, which is expected to issue shortly, will contain among other things extensive contributions to the knowledge of the life histories of aquatic insects, especially dragon flies, may flies, and caddis flies, and a few very interesting forms of Neuroptera and Diptera.

Although the medullary substance of the brains of most vertebrates has been rather fully studied, this portion of the ungulate brain, for some unknown reason, has received very little attention.

To remedy this defect Schellenberg (*Jena. Zeitschr.*, Bd. XXXIV, p. 113) has made an extended study of the medullary parts of the brains of goats, sheep, oxen, horses, and swine. In all these the centrum ovale is relatively small. The excessive size of the fibrous masses in the frontal lobes of swine is attributed to the well-developed sense of smell in these animals. In a similar way the great masses of medullary substance in the occipital lobes of the goat are supposed to be associated with the well-known quickness of sight of this animal. The fornix was about equally developed in all the ungulates studied, but the corpus callosum was relatively most prominent in the goat. As this organ is suspected of being connected with the associative operations of the cortex, its great size in the goat may be an indication of the rather remarkable psychical qualities of this animal as contrasted with sheep, etc.

BOTANY.

The Phytogeography of Nebraska [1] appears in a new and revised edition, in the preface to which the authors state that the greater portion of the first edition was destroyed in a fire that consumed the publisher's buildings. We cannot but rejoice in the calamity, for we ever felt that the form in which the work was cast was an injustice to its exceeding high merit and true worth. We cannot, however, but regret that the opportunity was not taken advantage of to carry the revision still farther. In our opinion it would have been better to have entirely reëdified the structure on a new foundation. The very excellent material was deserving of this. Rapid as has been the evolution of the two volumes, — witness the timely insertion relative to frequence and abundance, so conspicuously absent from the first edition ; the better treatment of the important factor of light, — these but examples of numerous improvements, — yet we cannot but feel that the present method of treating the habitat group is the pernicious root of much evil that afflicts our ecological classification. The habitat group should be relegated to an inferior position, or better abolished altogether, than as at present producing turgidity in what would by a more logical treatment be perfectly clear. Without

[1] Pound, Roscoe, and Clements, F. E. *The Phytogeography of Nebraska.* I. General Survey. Published by the Botanical Seminar of the University of Nebraska. Lincoln, 1900. Second edition. 422 pp., with four maps.

doubt, when the terminology and classification shall have become settled into a more consistent form, a more lucid, logical, and workable method will result. Future authors of similar treatises are hardly likely to adopt our authors' treatment of biological and ecological relations, grouping all but the larger families under cohorts. Would it not be better to incorporate much of this information in the description of formations, and the remainder under ordinal and specific caption in the descriptive lists of Nebraskan plants issued in other volumes, and to which this work is in a manner the introduction?

Whatever of deficiency the work possesses, however, is entirely of form. The work itself is of such high merit that it will bear any amount of criticism, and the indication of its defects will but bring into prominence its great excellence. The energy and enthusiasm of its authors are everywhere evident; but, having to find their own path, since the European masters of this new department of science could but indicate the direction, they have had, with often inept term, to translate or invent new phrases to fit the new conditions here presented. Again they have been at some disadvantage in their field of operations, since but few states of the Union offer less topographic diversity than Nebraska. With scarcely any rock exposure whatever, it was not a propitious field in which to study the chemical composition of soils and the consequent result on vegetation, particularly in its opposite phases as illustrated in semi-mountainous regions where on calcareous and siliceous substrata interesting and hitherto little analyzed or described conditions prevail. The groups of plants below the Pteridophyta seem to play but a very insignificant part in Nebraska, and students elsewhere will find in these lower groups much more that is noteworthy, and the increased attention constantly being paid to the lower cryptogams will cause a fuller treatment to be thoroughly appreciated.

The work, however, as it stands cannot be too highly commended and recommended to botanical students and workers, to many of whom indeed it is indispensable. Teachers and others may fitly use it as supplementary to a study of plant physiology, of which it is a concrete example. Apart from its high value as displaying the floral covering of a large territory, purely as a work on phytogeography and ecology it is at present by far the best American work we have. It is an example of what may be done under efficient leadership and with proper enthusiasm. Great credit is due to the authors and their colleagues. It has required a vast amount of labor to collate

such a mass of useful and thoroughly reliable information, and when we consider the painstaking care and discrimination with which it has been done, we cannot sufficiently thank the authors, Professor Bessey, to whom the inception of the work was due, and the several workers who are given credit in the preface. Their work is undoubtedly destined to exert a far-reaching influence and act as a stimulus everywhere. Is it too much to hope that before long every state and even much lesser divisions may be as well explored botanically as Nebraska?

COLTON RUSSELL.

The Cyclopedia of American Horticulture.[1] — The third volume of this important work, the earlier volumes of which were noticed in the *Naturalist* for April and September, 1900, sustains the high character with which the Cyclopedia began, — as, indeed, was to be expected, since the work as a whole was planned and the preparation of the later volumes well in hand before the appearance of the first volume. Leaving a fuller notice of the entire work until the concluding volume shall have been received, which will scarcely be later than autumn, it may be said now that among the subjects of special interest in the present volume are the revisions of Narcissus, Nymphæa, Pæonia, Papaver, and Pelargonium, representatives of which are commonly cultivated in our flower gardens in the open air; Nepenthes, Odontoglossum, Oncidium, Oxalis, and Primula, treated as house plants; the genera Opuntia, Picea, Pinus, Populus, Prunus, Pyrus, and Quercus, of botanical interest; the Orange, Peach, Pear, and Plum, of further interest to the fruit-grower; Orchids and Palms, of comprehensive gardening contents; and instructive articles on the physiology of plants, and plant breeding.

T.

The Flora of Cheshire. — J. Byrne Leicester Warren, Lord de Tabley, a man little heard of in this country as a botanist, but one of the most painstaking followers of one branch of that science, of the passing generation, affords a good illustration of the versatility of the English gentleman, for he was at once a poet of no mean attainments, an authority on numismatics, a conservative politician, and a man one of whose principal pleasures through life was direct and interested contact with nature. A quarter of a century ago he

[1] Bailey, L. H., and Miller, W. *Cyclopedia of American Horticulture, N–Q.* New York, The Macmillan Company, 1901. xv + 432 pp., 11 pls., 606 figs.

had prepared a manuscript flora of the county of Cheshire, but did not publish it. At the time of his death, in 1895, a new manuscript, except for a few late gamopetalous orders, had been fairly completed, and because of the wish of his sister, Lady Leighton, this was edited and revised by Spencer Moore and published a little over a year since.[1]

Few local floras are prefaced by poetry, original or copied, and one is given to looking askance at a scientific work in any part of which rhyme is encountered; and yet *The Flora of Cheshire* of De Tabley is really excellent, applying Watson's principles of distribution in a careful census of the plant growth of an interesting district, the real value of which is emphasized by the simple statement of his editor that in compiling the orders omitted from his later manuscript, though the earlier manuscript and certain memoranda found among the author's papers were used, this portion of the work is perforce left imperfect.

If with the present writer any others who handle the book desire a little deeper glimpse into the life of its author, they will find a further sketch of his life in the *Journal of Botany* for February, 1896.

T.

Notes. — The *Proceedings of the Society for the Promotion of Agricultural Science* for 1900 contains the following botanical papers: Beal, Syllabus for a short course on grasses and other forage plants; Munson, The development of a tomato hybrid; Tracy, Individual prepotency in plants of the same breeding; Chester, The chemical functions of certain soil bacteria; Galloway, Twenty years' progress in plant pathology; Trelease, The botanic garden as an aid to agriculture; Halsted, Seven years of experiments with bush beans; Rowlee, The value of willows in retaining the banks of streams; Bolley, The course of the hyphal filaments of Tilletia in the body of the wheat plant; Pammel, The course in cryptogamic botany; Pammel, The weedy plants of Iowa.

In the *Botanical Magazine* of Tōkyō, for January 20, Mr. Hemsley publishes a new genus of Bixineæ, under the name Itoa, given it in honor of Dr. Keisuké Ito, the Nestor of Japanese botanists, who recently died at the advanced age of ninety-nine, and his grandson, Dr. Tokutaro Ito, also a well-known botanist; and a figure of the type

[1] Tabley, Warren de. *The Flora of Cheshire.* Edited by Spencer Moore, with a biographical notice of the author by Sir Mountstuart Grant Duff. London, Longmans, Green & Co., 1899. cxiv + 399 pp., portrait and map.

species, *Itoa Orientalis* is published in *Hooker's Icones Plantarum* for February.

A series of lithographic illustrations of Cactaceæ, under the direction of Dr. Schumann, is appearing from the press of J. Neumann of Neudamm, under the title *Blühende Kakteen*. The two fascicles thus far issued contain rather indifferently colored habit sketches of flowering plants, which could be made far more valuable by the addition of detail analysis of pulvini and floral structure.

Mr. Bicknell writes on the nomenclature of Agrimonia in New England, in the *Bulletin* of the Torrey Botanical Club for February, which further contains notes on the insular flora of Mississippi and Louisiana by Lloyd and Tracy, The home of *Botrychium pumicola* by Coville, North-American Plantaginaceæ by Morris, and a revision of the North-American species of Heterocladium by Best. Dune plant communities are well shown in the plates accompanying the article by Professors Lloyd and Tracy.

Further descriptions of East-American species of Cratægus, by W. W. Ashe, are separately printed from the *Journal of The Elisha Mitchell Scientific Society*, under date of December 20.

Cotyledon purpusii, of California, is figured on plate 7713 of *Curtis's Botanical Magazine*.

A paper on the sunflower, *Helianthus annuus*, by Professor Wiley, constitutes *Bulletin 60* of the Division of Chemistry of the United States Department of Agriculture.

Forms and hybrids of several species of Chenopodium are discussed by Dr. J. Murr, in recent numbers of the *Oesterreichische Botanische Zeitschrift* and *Deutsche Botanische Zeitschrift*.

Anatomical studies of *Chamærops humilis*, *Phœnix dactylifera*, and their supposed hybrids for which Naudin proposed the generic name Microphœnix, by Bargagli Petrucci, published in Vol. XIV of *Malpighia*, are held to demonstrate that the two supposed species of Microphœnix are not true hybrids, but merely forms of *Chamærops humilis*.

No. 15 of Holm's "Studies in the Cyperaceæ," in *The American Journal of Science* for March, deals with some species of Carex of the group Astrostachyæ.

The plumose *Asplenium ebeneum Hortonæ* is the subject of a note by its discoverer, in *The Plant World* for February.

A list of Alabama species of Cercospora, by Professor Carver, is published as *Bulletin No. 4* of the Experiment Station of the Tuskegee Normal and Industrial Institute.

Diseases of Antirrhinum, caused by *Colletotrichum Antirrihini* and an undetermined Phoma, are described by Stewart in *Bulletin No. 179* of the New York Agricultural Experiment Station.

A committee of the Vermont Botanical Club, with President Ezra Brainerd as chairman, has recently published a list of the spontaneous spermatophytes and pteridophytes of that state, as an extract from the *Twentieth Vermont Agricultural Report.*

A preliminary list of the flowering plants of North Dakota, by Bolley and Waldron, is published as *Bulletin No. 46* of the Experiment Station of that state.

Under the title "Collectanea ad floram Argentinam," Dr. Kurtz has reprinted from Vol. XVI of the *Boletin de la Academia de Córdoba* a series of critical notes on Argentine plants, a number of which occur also in the United States.

A first part, historical and bibliographic, of a Flora Romana, by Pirotta and Chiovenda, constitutes the opening fascicle of Vol. X of the *Annuario del R. Istituto Botanico di Roma.*

Die Flora der deutschen Schutzgebiete in der Südsee, by Schumann and Lauterbach, is a thick quarto volume, with a map and 23 plates, just issued from the Borntraeger press of Leipzig, and furnishes another evidence of the scientific activity of the Germans abroad as well as at home.

A seventh part of Koorders and Valeton's "Additamenta ad cognitionem floræ arboreæ Javanicæ," covering the orders Araliaceæ to Verbenaceæ, forms No. 42 of the *Mededeelingen uit s' Lands Plantentuin.*

The latest nomenclature development is an appeal "an den Landtag des Königreichs Preussen," for the suppression of Engler's *Das Pflanzenreich* as a menace to science. Needless to add that Dr. Otto Kuntze is the plaintiff in the case.

Continued American interest in nomenclature reforms and upheavals is shown by an incisive article by Mr. Fernald in *The Botanical Gazette* for March.

Dr. Cowles's "Physiographic Ecology of Chicago and Vicinity," in recent numbers of *The Botanical Gazette*, is an interesting presentation

of an interesting subject, and, like his earlier work, is illustrated by process reproductions of well-chosen photographs.

An ingenious door device for herbarium cases is described and figured in the report of the Director of the Field Columbian Museum of 1899–1900, recently issued as *Publication 52* of that institution.

The vexed question of the preservation of herbarium specimens by impregnation with poisons is rediscussed by Paiche in No. 3 of the current volume of the *Bulletin de l'Herbier Boissier*.

A biographic sketch of J. G. Agardh, by Magnus, is published in the *Naturwissenschaftliche Rundschau* for February 28.

A biographic sketch, with portrait, of the late Thomas A. Williams appears in *The Asa Gray Bulletin* for January, a journal of which Professor Williams was editor-in-chief at the time of his death.

Portraits of Thomas Meehan and Frederick Law Olmsted are published in *The American Florist* of March 23.

PALEOBOTANY.

The Jurassic Flora of Great Britain.[1] — The present contribution from the pen of Mr. Seward, which will find a warm welcome from paleobotanists generally, deals with the fossil plants from the Inferior Oölite of the Yorkshire coast and is presented in the form of an illustrated catalogue, which is evidently designed to serve as the basis of further systematic treatment of the species, as well as of a more ample discussion of stratigraphical relations. In the present volume, therefore, the author attempts little beyond an endeavor to record the location of the various types found; to discuss the different species historically; to illustrate each type by excellent drawings; to institute a preliminary comparison with the Jurassic floras of other countries, and to simplify the nomenclature. Generic and specific diagnoses are presented only in special cases.

The material utilized is primarily that contained in the British Museum and represented by six different collections, of which the specimens derived from the collection of the late William Bean of Scarborough, by purchase in 1859, constitute the most important elements. Another section of the Bean collection is deposited in

[1] Seward, A. C. A Catalogue of the Mesozoic Plants in the Department of Geology, British Museum, Part III. The Jurassic Flora. London, 1900. Large 8vo. 341 pp., 21 plates.

the Museum of the Yorkshire Philosophical Society at York. The study of the material contained in these two museums has been supplemented by an examination of specimens in the Museums of Cambridge, Whitby, Scarborough, Oxford, Manchester, Newcastle, and Leeds, all of which are rich in collections of Yorkshire coast plants, and also of specimens in the collections at Paris, Lund, Stockholm, and other continental museums.

The author's experience shows that the identification of type specimens which have become so widely distributed is a very difficult and often fruitless task, and his appeal for some definite system whereby such important material may be centralized and the types thereby preserved and made accessible, is one which must meet with strong sympathy from paleobotanists elsewhere.

The Cliff sections of Jurassic plant-bearing strata exposed along the Yorkshire coast from Whitby to a few miles south of Scarborough have afforded unusually rich data bearing upon our knowledge of Mesozoic vegetation, and Mr. Seward points out that the flora of this particular district is the richest among Mesozoic floras from British localities, both as regards the number of species and the abundance of material, and that it is scarcely surpassed by any assemblage of fossil plants from extra-British regions. The large amount of this material which has found its way into various European collections has resulted at various times in partial descriptions by Brongniart, Sternberg, and other continental paleobotanists. As long ago as 1828, Brongniart described twenty-two species of these plants, and during the period from 1831–37, Lindley and Hutton published forty-seven species. In 1874 Professor Phillips recorded ninety-five species in the last edition of his work. At different times various other authors have published minor lists, but the most important contribution from a numerical point of view was that of Fox-Strangways and Barrows, who recorded one hundred and seven species in Vol. II (Yorkshire) of the *Geological Survey Memoirs*. But up to the present date no systematic attempt has been made to deal with the flora exhaustively and ascertain its geographical distribution; to compare it with older and younger floras, as also with recent species; to determine the conditions under which the plants grew, and to recognize the most characteristic species with a view to their employment as indices of geological age. This task has now been assumed by Mr. Seward after the lapse of forty-two years, and in the catalogue before us we are presented with the initial results of his studies.

An examination of extra-British Jurassic plants presents in convenient form an approximate comparison of the Jurassic floras of the various countries of the world, and the probable identity of such species with, or their resemblance to, British types is made clear by the use of a tabular presentation.

The present studies offered some conclusions of interest, of which the following may be noted:

The Jurassic flora shows a great preponderance of ferns and cycads, with relatively few conifers, and a remarkable paucity of the Equisetales and Bryophyta, in all of which features it exhibits a striking similarity to the flora of the Wealden as described in previous British museum catalogues, while they appear to be directly connected by a few apparently identical species, such as *Matonidium gœpperti*, *Ruffordia gœpperti*, and *Ginkgo digitata*, which are common to both floras.

Among the Equisetales the generally large size of the stems indicates a much nearer approach to the arborescent forms of the Triassic and Palæozoic than to the diminutive representatives found among the modern horsetails. In *Equisetites columnaris*, which is one of the most common and characteristic plants of the Yorkshire flora, the author finds evidence that the small seams of coal which occur in strata of the Estuarine series, were formed in part, if not entirely, from the remains of the Equisetaceous plants which flourished in the Jurassic swamps.

Ferns of the Sagenopteris and Cladophlebis types, while often abundant, afford little satisfactory evidence of relationship, which is much more clearly indicated by the Matonineæ and Dipteridinæ, which were abundantly represented in Jurassic time, and also by the Osmundaceæ and Cyatheaceæ. The Schizeaceæ were also represented by a few doubtful examples, but the Gleicheniaceæ and the Marattiaceæ are as yet unknown elements in the Yorkshire coast flora. From the types so far recognized it appears that this flora finds its closest resemblances among existing species in the Southern Hemisphere, where the Malayan *Matonia pectinata*, the Asiatic *Dipteris*, *Dicksonia arborescens* of St. Helena, and *Todea barbara* of New Zealand and Australia offer the closest parallelisms.

Among the Ginkgoales, both Ginkgo and Baiera are characteristic of the Jurassic floras, and they appear to have extended back through the Triassic into the Permian. Their extreme northern range points with considerable force to a vigorous development of the Ginkgoales during later Mesozoic time.

The Jurassic in Great Britain, as in North America, was essentially the Age of the Cycads, a fact strongly emphasized by the Yorkshire flora where Williamsonia, Otozomites, and Nilssonia formed conspicuous elements.

As already pointed out, the Coniferæ are much less abundant in this flora than either the ferns or the cycads, but the evidence so far obtained makes it impossible to determine how far this is to be accepted as an expression of their actual relation to the original flora, since local conditions may have operated to exclude a large proportion of such plants from preservation as fossils. The nearest existing types appear to be represented chiefly by various species of Araucaria, although Podocarpus is also suggested by *Nageiopsis anglica*. The Abietineæ, which assume an important position in the Wealden and Lower Cretaceous floras, have no well-defined representatives in the Yorkshire flora.

So far as any general conclusions are justifiable upon the basis of the present studies, it would seem probable that in seeking comparisons between the Jurassic flora of the Yorkshire coast and the vegetation of the present time, we must turn to the southern tropics. In the general character of the vegetation, therefore, as also in the luxuriant growth of Equisetums and ferns, we observe evidence not only of a moist climate, but also indications that the climate of England during Jurassic time must have been considerably more tropical than at present.

D. P. Penhallow.

QUARTERLY RECORD OF GIFTS, APPOINTMENTS, RETIREMENTS, AND DEATHS.

EDUCATIONAL GIFTS.

Albion College, Michigan, $10,000, for a library building, from Mrs. C. T. Gassette.

Alleghany College, Pennsylvania, a conditional gift of $60,000.

American Museum of Natural History, New York, $1500, from John L. Cadwalader, for mounting birds.

Armour Institute, $1,000,000, from Mrs. P. D. Armour and J. Ogden Armour.

Barnard College, $5000, from Jefferson Seligmann.

Baylor University (Texas), $60,000, from George W. Carrol, for a science building.

Bethany College, $240,000, by the will of the late R. S. Walton of Philadelphia.

Brown University, $150,000, for a library building; $500,000, for its endowment, and the unrivaled John Carter Brown Library of Americana, from John Nicholas Brown.

Columbia University, $10,000, by the will of Benjamin D. Silliman.

Cornell University, $10,000, from Mrs. Roswell P. Flower, for the library of the Veterinary College.

Creighton University (Omaha), $75,000, from John A. Creighton.

Cumberland, Maryland, Public Library, a conditional gift of $25,000, from Andrew Carnegie.

Dartmouth College, $100,000, from Edward Tuck, for a building for the school of administration and finance; $10,000, by the will of Mrs. Susan A. Brown, for the philosophical library.

Des Moines College, Iowa, a conditional gift of $15,000, from John D. Rockefeller.

Galesburg, Illinois, Public Library, a conditional gift of $50,000, from Andrew Carnegie.

Harvard University, $5000, by the will of Jacob Wendell, for a scholarship.

Lafayette, Indiana, $15,000, from Mrs. Robert H. Hitt and Mrs. L. Diaz Abertini, for public library purposes.

Lewiston, Maine, a conditional gift of $50,000, for a public library, from Andrew Carnegie.

Marion, Indiana, Public Library, a conditional gift of $50,000, from Andrew Carnegie.

Mercer College, Georgia, a conditional gift of $15,000, from John D. Rockefeller.

Mt. Vernon, N. Y., Public Library, a conditional gift of $35,000, from Andrew Carnegie.

New York City, $5,200,000, for branch public libraries, from Andrew Carnegie.

Oberlin College, $150,000, from various sources, being half of the sum necessary to secure the conditional gift of $200,000 from John D. Rockefeller.

Phillips Academy (Andover), $150,000, from an anonymous donor, for a department of archæology.

Port Jervis, N. Y., Public Library, a conditional gift of $20,000, from Andrew Carnegie.

Princeton University, $100,000, from Henry S. Little, for a new dormitory.

Richmond College, Virginia, a conditional gift of $75,000, from John D. Rockefeller.

St. Louis, $1,000,000, from Andrew Carnegie, for a public library.

Schenectady Public Library, a conditional gift of $50,000, from Andrew Carnegie.

Teachers' College, New York, $100,000, from an anonymous giver.

Tulane University, about $2,000,000, by the will of Mrs. Josephine L. Newcomb, for the Sophie Newcomb College for Women.

University of California, $24,000, from Mr. D. O. Mills, of New York, for an astronomical expedition.

University of Minnesota, $50,000, from John B. Gilfillan.

University of Pennsylvania, $200,000, from Randolf Morgan, for a physical laboratory.

University of Southern California, a conditional gift of $25,000, from Mrs. Anna C. Hough.

Watertown, N. Y., $60,000, from Mrs. Emma Flower Taylor, for a public library.

Wellesley College, $25,000, from H. H. Hunnewell, for the botanical department; $15,000, by the will of Miss Mary Shannon.

Western Reserve University, $12,000, from H. M. Hanna.

Yale University, $110,000, by the will of Benjamin D. Silliman: $100,000, from an anonymous donor, for a medical school building: $6000, from the family of the late Robert Callender, for a scholarship; $10,000, from Jonathan Bulkley, for a fellowship; $50,000, by the will of George T. Bliss; $25,000, from William C. Whitney: $10,000, from Mrs. S. H. Camp, for the library of the philosophical department.

APPOINTMENTS.

Alexis P. Anderson, curator of the herbarium of Columbia University. — S. M. Bain, professor of botany in the University of Tennessee. — Dr. Joshua W. Beede, instructor in geology in the University of Indiana. — Dr. Robert Bell, director of the geological survey of Canada. — Dr. W.

Benecke, docent for botany in the university at Kiel, titular professor. — Dr. H. Borultan, docent for physiology in the university at Göttingen, titular professor. — John A. Bownocker, professor of inorganic geology in the Ohio State University. — Dr. Brauer, docent for geology and paleontology in the Munich Technical School. — Dr. August Brauer, docent for zoölogy in the university at Marburg, titular professor. — Dr. Hermann Braus, of Würzburg, professor extraordinary of anatomy in the University of Heidelberg. — E. J. Butler, official botanist to the Indian government. — Dr. Alexander F. Chamberlain, acting assistant professor of anthropology in Clark University. — Henry E. Crampton, adjunct professor of zoölogy in Barnard College. — Samuel M. Coulter, instructor in botany in Washington University. — Dr. August Denckmann, geologist in the Berlin geological Anstalt. — Dr. Karl Escherich, docent for zoölogy in the university at Strassburg. — Dr. Richard Ewald, professor of physiology and director of the physiological institute in the university at Strassburg. — A. W. Evans, assistant professor of botany in Yale University. — Miss Margaret C. Ferguson, instructor in botany in Wellesley College. — George I. Finlay, assistant in geology in Columbia University. — E. J. Garwood, professor of geology and mineralogy in University College, London. — Georg Geyer, chief geologist of the Austrian Geological Survey. — Dr. Ernst Gilg, curator of the botanical museum of the University of Berlin. — H. E. Gregory, assistant professor of physical geography in Yale University. — W. Gunn, district geologist of the British Geological Survey. — Dr. A. C. Haddon of Dublin, Junior Fellow in Christ's College, Cambridge. — Dr. Hauptfleisch of Würzburg, assistant in botany in the Stuttgart Technical School. A. S. Hitchcock of Kansas, assistant agrostologist in the U. S. Department of Agriculture. — John Horne, assistant director (for Scotland) of the British Geological Survey. — Dr. H. S. Jennings, assistant professor of zoölogy in the University of Michigan. — Dr. W. Karawaieff, director of the zoölogical station at Sebastopol. — Dr. K. Keilhack, professor of geology in the Berlin Mining School. — W. E. Kellicott, assistant in zoölogy in Barnard College. — Dr. F. Kossmat, adjunct of the Austrian Geological Survey. — G. W. Lamplugh, district geologist of the British Geological Survey. — Dr. C. F. W. McClure, professor of comparative anatomy in Princeton University. — Dr. Friedrich Maurer, professor of anatomy and director of the anatomical institute in the university at Jena. — Dr. May, docent for zoölogy in the Carlsruhe Technical School. — Professor A. D. Mead, member of the Rhode Island Fish Commission. — Dr. A. Mertens, chief of the city museum at Magdeburg. — Dr. L. Milch, professor of mineralogy in the university at Breslau. — William J. Moenkhaus, assistant professor of zoölogy in the University of Indiana. — L. de Nicéville, entomologist in the Indian Museum, Calcutta. — Dr. Franz Nissl, professor extraordinary of psychiatry in the university at Heidelberg. — Dr. E. Overton, professor extraordinary of botany in the university at Würzburg. — Dr. E. Palla, professor extraordinary of botany in the university at Graz. —

B. N. Peach, district geologist of the British Geological Survey. — Dr. A. Penther, assistant in the zoölogical division of the Vienna Hofmuseum. — O. Porsch, assistant in the botanical institute at Graz. — Dr. H. Potonié, docent for paleobotany in the university at Berlin, and geologist in the Berlin Geological Anstalt. — Charles S. Prosser, professor of geology and head of the department in the Ohio State University. — Dr. Federico Raffaele, professor of zoölogy in the university at Messina. — Dr. Walter M. Rankin, professor of invertebrate morphology in Princeton University. — Clement Reid, district geologist of the British Geological Survey. — Dr. F. Reinitzer, professor of botany in the Graz Technical School. — Herbert F. Roberts, professor of botany in the Kansas Agricultural College. — Dr. Felix Rosen, professor of botany in the university at Breslau. — August Rosiwal, geologist of the Austrian Geological Survey. — Dr. M. Rudolphi, docent for physiology in the Darmstadt Technical School. — H. W. Shimer, assistant in paleontology in Columbia University. — Dr. J. Siemiradzki, professor extraordinary of geology and paleontology in the university at Lemburg. — Johann F. Snelleman, director of the Leiden Museum of Ethnology. — J. Edward Spurr, of the U. S. Geological Survey, geologist to the Sultan of Turkey. — Dr. J. Stafford, lecturer on zoölogy at McGill University. — Aubrey Strahan, district geologist of the British Geological Survey. — C. Fox Strangeways, district geologist of the British Geological Survey. — J. J. H. Teall, director of the Geological Survey of Great Britain and Ireland. — Arthur Thompson, professor of anatomy in the Royal Academy, London. — Dr. A. Voeltzkow, the zoölogist of Berlin, professor. — Dr. Weber, docent for mineralogy in the Munich Technical School. — H. B. Woodward, assistant director (for England and Wales) of the British Geological Survey. — Jay Backus Woodworth, assistant professor of geology in Harvard University. — Dr. A. Zahlbruckner, Custos of the botanical section of the Hofmuseum, Vienna.

RETIREMENTS.

Professor R. Blanchard has retired from the position of general secretary of the Zoölogical Society of France after a service of twenty-three years. — Professor Spiridion Brusina has resigned from the control of the Zoölogical Museum at Agram, which he founded thirty-three years ago. — Dr. M. Reess has retired from the professorship of botany in Erlangen.

DEATHS.

Dr. J. G. Agardh, the Swedish algologist, at Lund, Sweden, January 17, aged 88. — Andrea Balestra, conchologist, in Bassano, February 10, aged 48. — James Bennie, formerly of the Geological Survey of Scotland, January 28. — Dr. Guilio Bizzozero, the well-known pathologist of Turin, April 5, aged 55. — Dr. Frederick J. Brockway, assistant demonstrator of

anatomy in Columbia University, April 21, aged 41. — Thomas Benton Brooks, geologist and mining engineer, Nov., 20, 1900. — Paul Chaix, formerly professor of geography in the University of Geneva, aged 93. — The missionary, Armand David, the indefatigable collector of Chinese insects and birds, in Paris, November 10, aged 74. — George M. Dawson, director of the Geological Survey of Canada, March 2, aged 55. — F. K. M. Feofilaktow, formerly professor of geology in the university at Kiew, Russia. — Dr. John Gardiner, professor of biology in the University of Colorado, November 26, aged 38. — Dr. John W. Griffith, the senior editor of the well-known "Micrographic Dictionary," at Camberwell, England, aged 81. — David S. Holman, well known as a microscopist, in Philadelphia, May 13. — Baron Keiské Ito, professor of botany in the University of Tokyo, January 21, aged 99. — W. Iversen, zoölogist and librarian of the St. Petersburg Technical School, November 28. — Arthur Coppen Jones, bacteriologist, at Daavos Platz, Engadine, March 8, aged 35. — Dr. John Kloos, professor of geology and mineralogy in the Braunschweig Technical School. — Professor Christian Frederik Lütken, the celebrated Danish zoölogist, February 7. — P. O. Massalongo, entomologist, in Verona, February 23. — Dr. N. Melnikow, professor of zoölogy in the university at Kasan, January 26, aged 60. — Professor Karl Müller, anatomist of domestic animals, at Carlottenburg, near Berlin, March 6. — Dr. N. J. C. Müller, professor of botany in the Forestry School at Münden, Hannover, January 12, aged 58 years. — Dr. Robert Pohlmann, geologist and curator of the Natural History Museum at Santiago de Chili. — Dr. Thomas C. Porter, professor of botany for thirty-four years in Lafayette College, April 27, aged 79. — Audubon Whelock Ridgway, ornithologist, in Chicago, aged 24. — Dr. A. Weissbach, professor of mineralogy in the Freiburg (Saxony) school of mines, February 26, aged 67. — E. Weissleder, mineralogist, in Leopoldshall, January 28, aged 59. — William Jay Youmans, for several years editor of *Popular Science Monthly*, at Mt. Vernon, N. Y., April 10, aged 62.

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Volume for 1898. 343 pages. Illustrated. Mailing price, $2.90; to teachers, $2.75.
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IN THEIR WIDEST SENSE

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THE TEXAN KŒNENIA.[1]

AUGUSTA RUCKER.

THIS most interesting microthelyphonid was discovered last May in the neighborhood of Shoal Creek, near Austin, Texas, under stones in company with Campodea, Japyx, and Scolopendrella. A short description of it was given by Dr. W. M. Wheeler in the November *Naturalist*, under the title "A Singular Arachnid (*Kœnenia mirabilis* Grassi) occurring in Texas." The writer believed the Texas species to be identical with the Sicilian one figured and described by Drs. Hansen and Sorensen, and therefore wrote of it under that name. A number of specimens have since been examined *in toto* and in sections, and some interesting results have been obtained. It did not seem probable that the Texan Kœnenia had been imported, yet it seemed less probable, though our climate is much like that of southern Europe, that the two species were identical. Close microscopic examination has shown them to be two distinct species of the family Kœneniidæ.

Kœnenia has since been found in Siam and Paraguay and, like all archaic types, it will doubtless be found to be cosmopolitan

[1] *Contributions from the Zoölogical Laboratory of the University of Texas. No. 21*

in its distribution. A young Danish zoölogist has recently found in Siam a distinct species of Kœnenia which Dr. Hansen is to describe. Dr. Silvestri, the discoverer of the species from Paraguay (*K. grassii*), has promised me a few of his specimens in return for the Texan species, which I hoped to have for comparison before this paper was finished. I have likewise been unable to collect any *K. parvula*,[1] of which species Dr. Wheeler has found a single specimen, which he has briefly described in his paper (p. 233). When descriptions of these species are published a more correct idea can be framed of the valuable taxonomic characters of the hitherto unknown order.

Kœnenia wheeleri n. sp.

I desire now to name our principal Texan form after its discoverer, Dr. Wheeler, and to give along with its internal structure a short description of the characteristics which set it apart as a new and distinct species.

In the beginning I may say we have been more fortunate than Drs. Hansen and Sorensen in being able to distinguish the two sexes. It hardly seems possible that the males of Grassi's species could be so rare when they are so abundant in our species. In fact, in the material collected in the fall, the males predominated. Very few females were to be had then, and those few were so small and insignificant that it was thought they were the males. The criterion taken for distinguishing the sexes in this material was the opaque glistening body in the second abdominal segment of the female, the receptaculum seminis of Hansen. Unfortunately the seminal vesicles of the male are situated in the same region and have much the same appearance; hence Dr. Wheeler, in his interesting paper, was misled into thinking that the male was of the other sex. It was not until fresh material was collected this spring and sections made that the mistake was discovered. In size and general form the sexes are alike, and it was only after examining sections that one could say for the first time that the animal possessing the more complex reproductive appendages is the male.

[1] I have the pleasure also of giving this species its name.

External Anatomy.

On comparing *K. wheeleri* with the figures and descriptions of Drs. Hansen and Sorensen for *K. mirabilis* the following differences are apparent: (1) the number and position of the hairs of the body; (2) the appendages of the reproductive orifice situated between the second and third segments of the abdomen; (3) the three pairs of prominent orifices on the ventral surface of segments four, five, and six, through which the lung sacs are everted; (4) the lateral sense organs of the cephalothorax; (5) the number of teeth on the two last joints of the cheliceræ.

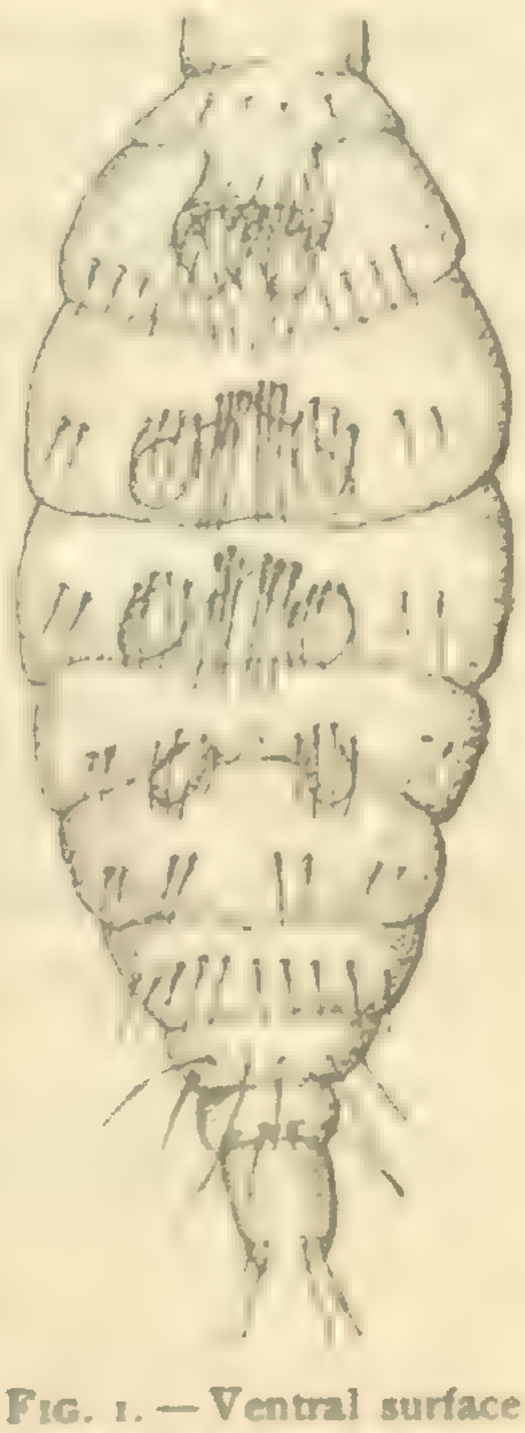


FIG. 1.—Ventral surface of the abdomen of male *K. wheeleri*

The hairs over the ventral surface of the abdomen of the Texan species are more numerous and are distributed in a manner quite different from those over the abdomen of the old-world form. In the second segment of the female there are three rows of plumulose setæ. The first row of six runs across the ventral surface anterior to the middle line and is continuous with the hairs of the dorsal surface. These form a belt around the second segment. The second row of six arises along the base of the triangular flap of the reproductive orifice. The third row is so irregular that it can scarcely be called a row. Here the hairs follow in a fashion the other two sides of the triangular appendage. Fig. 2 is a camera drawing of this portion of a specimen which has been treated with potassium hydrate. The figure clearly shows the arrangement of hairs over this region of the female. The dotted lines of the figure represent the portion of the organ which can be seen only by focusing through the triangular appendage.

In segment two of the male there are three primary rows of plumulose hairs. The first row, consisting of from four to six small setæ, runs across the ventral surface at about the middle of the segment and continues dorsally to form the circular row

of setæ. This second row of four small setæ extends across the middle of the shield-shaped appendage of the reproductive organs. The third set consists of two secondary groups, the first of which, containing eight hairs, runs across a sort of hem attached to the lower margin of the shield-shaped organ. The second set is made up of large plumulose spines arising from the tips of ten papillæ, four of which spring from the edge and six from under the edge of the hem. Fig. 3 is a careful camera drawing of this region of the male. The first row of setæ not on the reproductive appendage is not figured.

Segment three in both male and female has on the two blades of the reproductive appendages irregularly placed hairs which are of varying lengths. In a line posterior to the middle of the segment are eight other setæ in a row continuing with those of the dorsal surface to form the setigerous belt of segment three.

Most remarkable are the differences between segments four, five, and six of *K. wheeleri* and the corresponding segments of *K. mirabilis*. Concerning the fourth segment of Grassi's species, Drs. Hansen and Sorensen have written, "Provided on the ventral side in front of the middle with a wart-like protuberance which bears six stiff setæ, almost spines (*aculei*), arranged in two transverse rows, the foremost of which is arched and has four spines. Grassi seems to consider these spines sensory organs, an opinion we by no means share." In *K. wheeleri* segment four is provided on its ventral side with three pairs of hair groups. The first pair consists of three long backward-pointing setæ on each side of and near the midventral line. These setæ are situated on delicate chitinous flaps of the integument which arise in front of the middle of the segment. The second pair is made up of four much shorter backward-curving hairs arranged in an arched transverse row near the middle of the segment to the right and left, respectively, of the first pair. These hairs are most evidently for the protection of the delicate lung sacs when they are ejected, and for protection of their orifices when they are drawn in. The third pair consists of two small setæ in the same line and lateral to those of the second group. The former are continuous with the belt of setæ encircling the whole segment.

Of the fifth segment nothing is said concerning *K. mirabilis*, while the figures show it to be like segment seven. This is decidedly not the case in our species. The fifth segment is — as far as the setæ are concerned — a facsimile of the fourth.

Again, concerning the sixth segment of the Sicilian species, the Danish investigators write, "It is furnished on its ventral side with a rather strongly protruding wart, bearing a somewhat arched transverse row of six forward-curving setæ. We do not think these to be sensory organs either." In *K. wheeleri* the ventral surface of the sixth segment is in reality less prominent than that of the two preceding segments, for it is lacking in the first group of large hairs situated on the flaps on each side of the midventral line; the flaps, however, are retained. Fig. 1 is a ventral view of the abdominal exoskeleton of a male Kœnenia, which has been thoroughly cleaned of its cellular contents in KOH. In this specimen all six of the sacs are thrown out, and the protective function of the groups of four hairs is quite evident. All the setæ shown in this figure are plumulose; but under a magnification of about 120 diameters they barely appear to be so, and I did not attempt to represent this condition in the drawing.

It was only after repeated attempts that I succeeded in obtaining clear views of the reproductive appendages. In both sexes, segments two and three are conspicuous for their relatively enormous appendages. In the female the midventral surface of the second segment projects downward and backward into a triangular appendage, which is not emarginate at its apex, as in *K. mirabilis*. This projection almost covers a couple of heavily chitinized downward projections of the third segment.

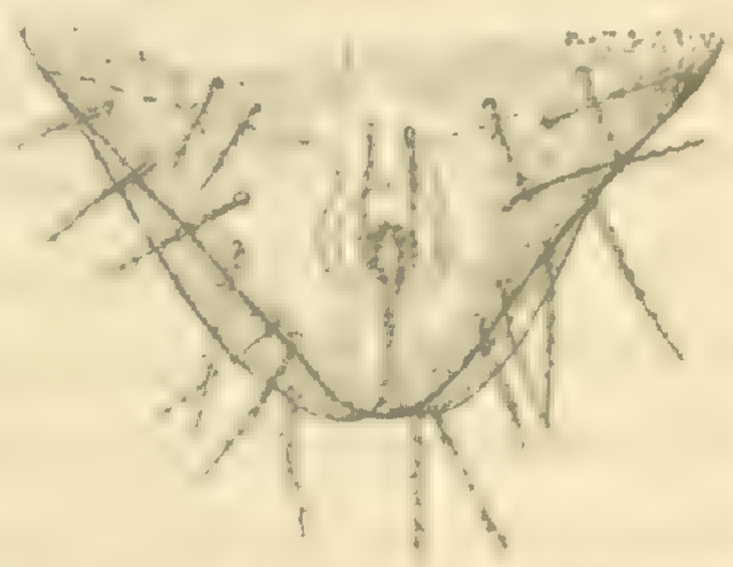


Fig. 2. — Reproductive appendages of female *K. wheeleri*. The round sac in the center of the figure is the receptaculum seminis.

The receptaculum seminis opens between these two appendages, while the reproductive organs open further forward into the vagina formed by the three appendages. Fig. 2 shows what I take to be the receptaculum seminis, while the reproductive orifice only shows in section. The male appendages are very

complex and difficult to explain. Fig. 3 will aid in making the account clear. The appendage of the second segment represents in surface view a truncated conical flap having at its base a hem which is notched in the midventral line. The hem near the outer sides of the flap projects into two papillæ, each of which terminates in a heavy spine. Projecting from the under surface of the hem are two pairs of large and one pair of small papillæ, with their corresponding spines. This papillate appendage partially conceals two trowel-shaped, strongly chitinized, downward and backward directed projections of the third segment. The accessory glands and vasa deferentia open near together, in the median line, where the posterior surface of the unpaired appendage is continuous with the anterior surfaces of the paired appendages.

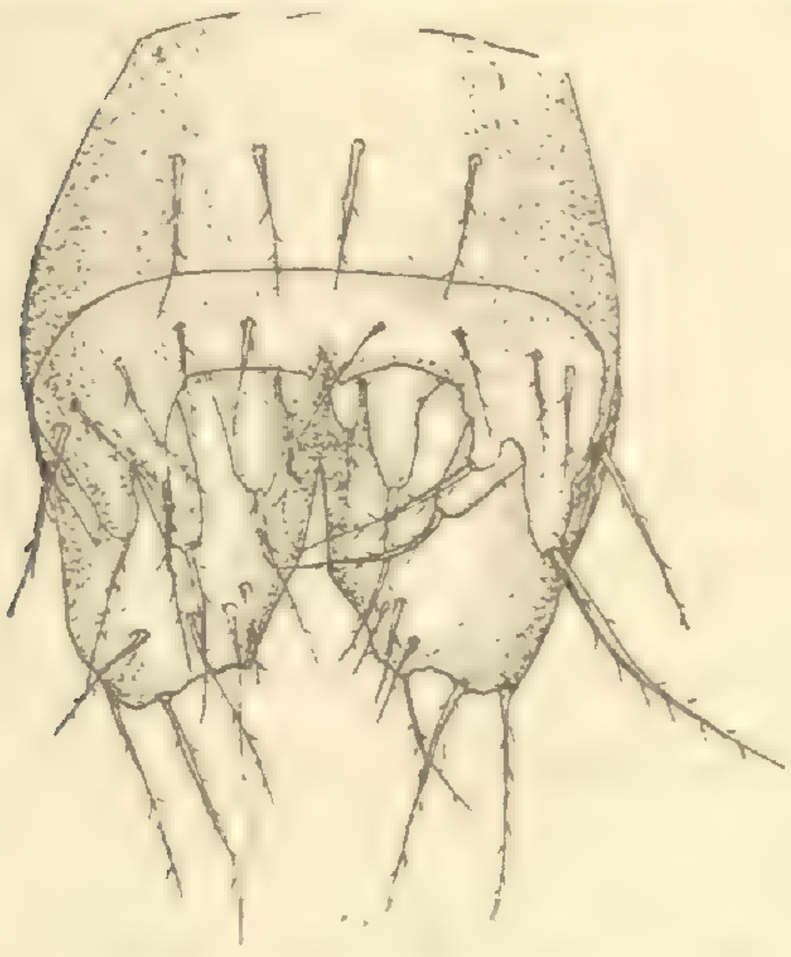


FIG. 3. — Reproductive appendages of male *K. wheeleri*.

Another important specific difference seems to be in respect to the lung sacs, organs which are evidently much more prominent in the Texan species. These organs must, in fact, be entirely lacking in *K. mirabilis*, for such careful observers as Drs. Hansen and Sorensen could not have entirely overlooked them. On examination of a few of our specimens, one cannot fail to observe peculiar little sacs projecting from the ventral surface sometimes of the fourth, sometimes of the fifth, sometimes of the sixth, and occasionally from all three segments. Again a specimen may be found in which all six sacs are invaginated, giving it the appearance of possessing three pairs of stigmatic apertures. Of these organs Dr. Wheeler writes: "In many specimens a delicate sac may be found evaginated from under a flap on all three segments. These sacs are in all probability lung books. They appear to be the only respiratory organs of Kœnenia apart from the delicate integument, which in so small an animal must of itself nearly suffice for respiratory purposes. If I am correct in regarding the above-described

sacs as lung books, they must represent those organs in an extremely simple form, in a form, moreover, which strongly suggests their origin from invaginated appendages serially homologous with those of the cephalic and thoracic segments."

The two anterior sensory organs do not appear different in any respect from the same organs of *K. mirabilis*. The lateral organs, however, though situated in about the same place, consist of three sensory rods each, instead of the two blades. These are short-pointed rods pressed close together and projecting, when at rest, forwards and outward. Fig. 4 is a camera drawing of these lateral sensory hairs, under a high magnification. In cross-section the hairs appear as three rings in contact with one another. I am unable to make out on the surface of these organs anything more than the minute projections which are found over the entire surface of the animal's body.

FIG. 4. — Lateral sense hairs.

The second and third joints of the cheliceræ, which form pinchers, in specimens examined for this special purpose, were found to be each provided with eight teeth. The teeth of the fixed portion are long and very acute, with barbs at the base; while the teeth of the movable joint are short, broad, and blunt.

The above are the most evident differences of the two species of Kœnenia, unless it be that there are more segments in the caudal flagellum of one than of the other. I have examined a number of complete specimens of both males and females, and find in every case that the tail is made up of fifteen segments. Grassi states for his species, which has been redescribed for all other points except this, that it possesses thirteen or fourteen joints.

Internal Anatomy.

In considering the internal anatomy of this minute animal, several difficulties have arisen which I fear I have not entirely surmounted. The extreme minuteness of the cells of the very delicate tissue enclosed in the comparatively heavy chitinous case makes microscopic study rather unsatisfactory.

Integument. — Drs. Hansen and Sorensen state, "As a peculiarity in Kœnenia, we think right to emphasize at once that its skin is but slightly chitinized, especially on the abdomen, where, consequently, there is no distinction between the (dorsal and ventral) plates and the pleura; so the expansion, which the abdomen must be capable of allowing, probably depends on the elasticity of this thin chitin itself." I think had these gentlemen attempted to section Kœnenia they would not have been so emphatic about the thinness of its exoskeleton. The chitinous cuticle, which rests on a delicate hypodermis, corresponds more nearly to that of most spiders, in that over the expanded abdomen it does not appear to form special plates. It also corresponds to spiders, in that it is a flexible or accordion-plaited covering, the folds of which run parallel with the long axis of the body. This arrangement thus allows of great expansion of the abdomen, its function being evidently the same as the folds in the late integument of the abdomen of Thelyphonus. Over the chelicerae labrum-hypostome and reproductive appendages the chitin is thick and yellow, while between the joints it is very thin. In the floor of the mouth the chitin is thrown into folds, running at right angles to the long axis of the body. This, in sagittal sections of the animal, gives it the appearance of possessing teeth. The entire chitinous surface of the animal is not smooth, but under high magnification appears to be covered with small dot-like elevations.

Kœnenia wheeleri is remarkable for the comparatively thick covering of hairs arising from its flexible cuticle. The smallest hairs are like down, covering the anterior surface of the labrum and the under surface of the hypostome. The longest and most delicate are the tactile hairs of the sixth, seventh, and eighth segments of the third pair of appendages. The broadest and heaviest spines are situated on the underside of the proximal joint of the chelicerae; otherwise the setæ are distributed as Dr. Wheeler has already shown. All the hairs over the body of Kœnenia, with the exception of the tactile and the very minute ones on the mouth appendages which are too delicate to be made out, are microscopically plumulose.

The muscles of Kœnenia are decidedly striated, like those of insects. They represent a condition of musculature which would be expected in so small and primitive an animal. Worthy of note are the two pairs of simple dorsal and ventral muscles of the abdomen and thorax. Other important muscles are those running from the roof and side of the thorax to the chelicerae. The muscles of the appendages need not be described, with the exception of those extending from the side of the thorax to be inserted on the thoracic appendages. These muscles arise on the sides of the thorax, opposite to their corresponding legs, and, crossing over just above the subœsophageal ganglion, become inserted on their proximal joints. The only other muscles that need to be mentioned are the primitive dorso-ventral muscles of the thorax and abdomen. These are decidedly a very striking feature in the abdomens of arachnids.

Nervous System. — One of the most singular things about Kœnenia is its large proportion of concentrated nervous substance. The concentration of the ganglia is almost equal to that of the Araneidæ. In this respect Kœnenia is even more specialized than Thelyphonus. There seems to be no reduction of nervous element here due to the absence of eyes, but, like all primitive types, it retains its cephalothoracic ganglia unmodified. The brain and subœsophageal ganglion unite to form one large mass perforated by the small œsophagus. The brain is enormous, occupying the entire dorsal portion of the head above the level of the œsophagus. It innervates the median and lateral sense organs, the labrum, and chelicerae. The subœsophageal ganglion covers the entire floor of the head and thorax, and shows in section swellings corresponding to each of the five pairs of appendages. With a slight constriction at the waist, the subœsophageal ganglion connects with a single abdominal ganglion which is situated in segments two and three, dorsal to the reproductive orifice. From this ganglion, nerves run to all parts of the abdomen and tail. In its nervous system Kœnenia is thus very unlike the Scorpionidea and differs from Thelyphonus in the relative size of the cephalothoracic ganglion and in the situation of the

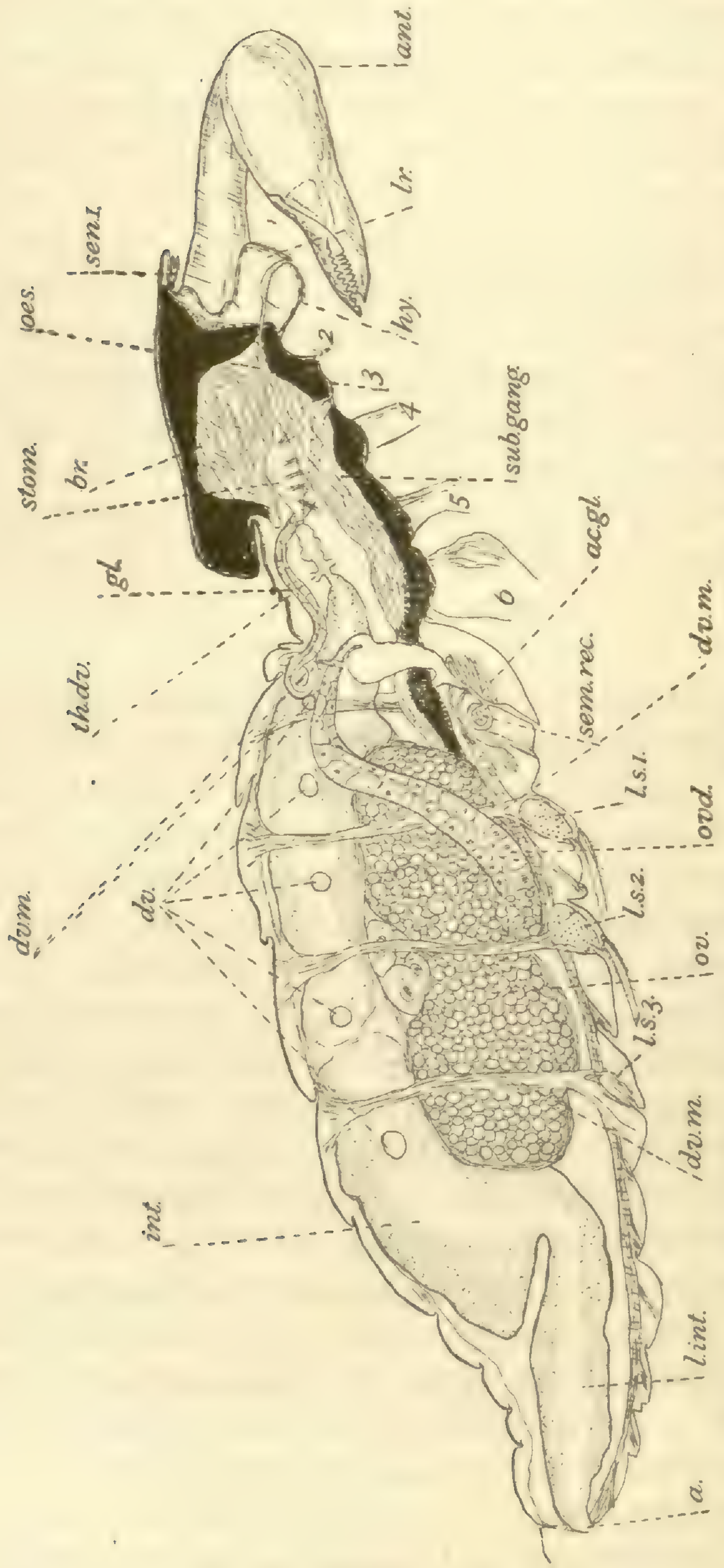


FIG. 5.—Diagrammatic sagittal section of a female *K. wheeleri*. *ant.*, cheliceræ; *ac.gl.*, accessory gland; *a.*, anus; *br.*, brain; *sub.gang.*, subœsophageal ganglion; *dv.*, diverticula; *dv.m.*, dorso-ventral muscles; *th.dv.*, thoracic diverticulum; *gl.*, coxal gland; *hy.*, hypostome; *lr.*, labrum; *int.*, intestine; *l.s.1, 2, 3*, lung sacs; *oes.*, œsophagus; *ov.*, ovary; *ovd.*, oviduct; *sem.rec.*, seminal receptacle; *sen.l*, anterior sensory hairs; *stom.*, stomach.

abdominal ganglion, which has not been drawn up toward the head in the latter, but remains in the eighth segment.

Digestive System. — The downward-curved, crescentic mouth leads into a strongly chitin-lined pharynx. This in turn runs into a very delicate œsophagus which penetrates the cephalothoracic nerve mass, only to dilate immediately into a pouch-like sucking stomach. This stomach is roofed over by the brain, while underneath it the subœsophageal ganglion extends. At the sides the brain is not continuous with the subœsophageal ganglion, thus leaving a passageway for muscles arising from the sides of the cephalothorax to enter and attach themselves to the stomach. When expanded to its utmost the stomach fits snugly in between the two ganglia, but when pulled on by the muscles it is flattened dorso-ventrally. The comparatively thick-walled stomach opens through a valve-like constriction into the exceedingly thin-walled intestine. The intestine, before it leaves the thorax, gives off a pair of small diverticula. It then passes into the abdomen, becoming much dilated, and giving off five shallow metameric pairs of diverticula, from the third to the seventh segments inclusive. These diverticula are very diagrammatically represented in Figs. 5 and 6, as are all the other organs, save the brain and the anterior portion of the digestive tract as far back as to the first pair of diverticula. At about the eighth segment the thick-walled large intestine begins. Unlike Thelyphonus, no Malpighian tubules are present, opening into the hind gut, before it terminates at the anus. On this point Kœnenia is most primitive, since it seems not yet to have reached the stage in which intestinal diverticula become modified as excretory organs. There are also no salivary glands present ; these would hardly be of any use to an animal living under such simple conditions. The intestine and diverticula are invariably filled with food particles, which have the appearance of yolk granules. Strange to say, — because of the conditions under which Kœnenia is found, — throughout the entire digestive tract no dirt ever appears. This goes to prove that the food is probably derived, as Dr. Wheeler has already suggested, from the eggs of animals with which it associates. The

digestive tract is thus admirably constructed for such an illegitimate practice as egg-sucking.

Excretory System. — I have succeeded in tracing the pair of tubular glands, "tappezzata d' un semplice strato di cellule epiteliali," of which Grassi speaks. According to him, these glands extend through a large part of the cephalothorax, and perhaps have their orifice in front of the third pair of limbs. These excretory organs in reality arise in the second segment of the abdomen, and after forming one or two convolutions run into and straight through the thorax, to terminate between the second and third pair of appendages. There being no Malpighian tubules in the small animal, this simple pair of coxal glands would seem to represent the only excretory organs, unless, indeed, the glandular cells around the respiratory sacs can be considered as possessing excretory functions. If this be the case, the eversible sacs will then have a double function of respiration and excretion like the vertebrate allantois. These cells are not represented in the drawings.

Respiratory Organs. — Respiration in so small an animal as Kœnenia must necessarily be very simple, and, if I have rightly interpreted the facts, we have in this minute Palpigrade the most primitive form of respiratory organs. These organs consist of the three pairs of lung sacs which are situated in segments four, five, and six, with their corresponding orifices on the ventral surface. They are evidently evaginated through the internal blood pressure. For each pair of sacs there is a pair of dorso-ventral muscles, corresponding to the dorso-ventral muscles of Thelyphonus, which have the function in Kœnenia of drawing in the everted sac appendages. These lung sacs possess on their inner surface (inner when they are evaginated) granular bodies which stain a deep blue with alcoholic carmen if they happen to be invaginated, but which take on a normal red stain when the sacs are thrown out. Often, in examining sections through the inverted sacs, one can hardly refrain from calling them tracheæ, so very much do they look like simple tubes. In truth, according to whether the sacs are pulled in by muscles, remaining contracted, or whether they have been pulled in by muscles that have immediately become

relaxed, allowing the sac to flatten dorso-ventrally and wrinkle, do we obtain diminutive tracheæ or simple lung books. After examining a great number of sections one cannot refrain from believing that simple sac tracheæ like those of Kœnenia may have given rise to both lung books and tracheæ in other arachnids. If this be the case, we may hold that Kœnenia, which possesses the simplest phase of these organs, the lung trachea (which are in reality abdominal appendages belonging to distinct body segments), is the most primitive of all Arachnoidea.

Circulatory System. — As to the circulatory system, the simplest condition possible exists. A definite heart has not yet made its appearance. The blood can have no regular course through the lacunæ and sinuses, and it probably makes its exchange of gases in the neighborhood of the lung sacs. There must be some definite region for the interchange of oxygen and carbon dioxide, for though Kœnenia is small, its exoskeleton is rather too thick to allow of a general surface respiration. I do not think that the dots over the entire surface of the chitin can be minute pores, which the spiders alone of all the arachnids possess, over the skin of the abdomen.

Reproductive System. — In the female the unpaired ovary begins as a blind tube in the seventh or eighth segment and extends into the third. From each side near the anterior end it is prolonged into two oviducts, consisting, for the greater part of their length, of large glandular cells — the largest cells, in fact, of the body. These ducts run forward and upward, becoming very small and thin-walled ; probably the last portion, for a short distance, being chitin-lined, as in Galeodes. In the second abdominal segment they become very much swollen, forming a sort of pouch on each side, filled with a gelatinous secretion, evidently derived from the gland cells of the oviduct. The duct continuing from each pouch or vesicle runs backward and downward to meet at the place of entrance in the vagina. It is this portion of the reproductive organ, the vitelline vesicles and their terminal ducts, of which Hansen and Sorensen write : "In the second abdominal segment there is an organ which shows the same peculiar luster and refraction of light which one of us knows so well for the

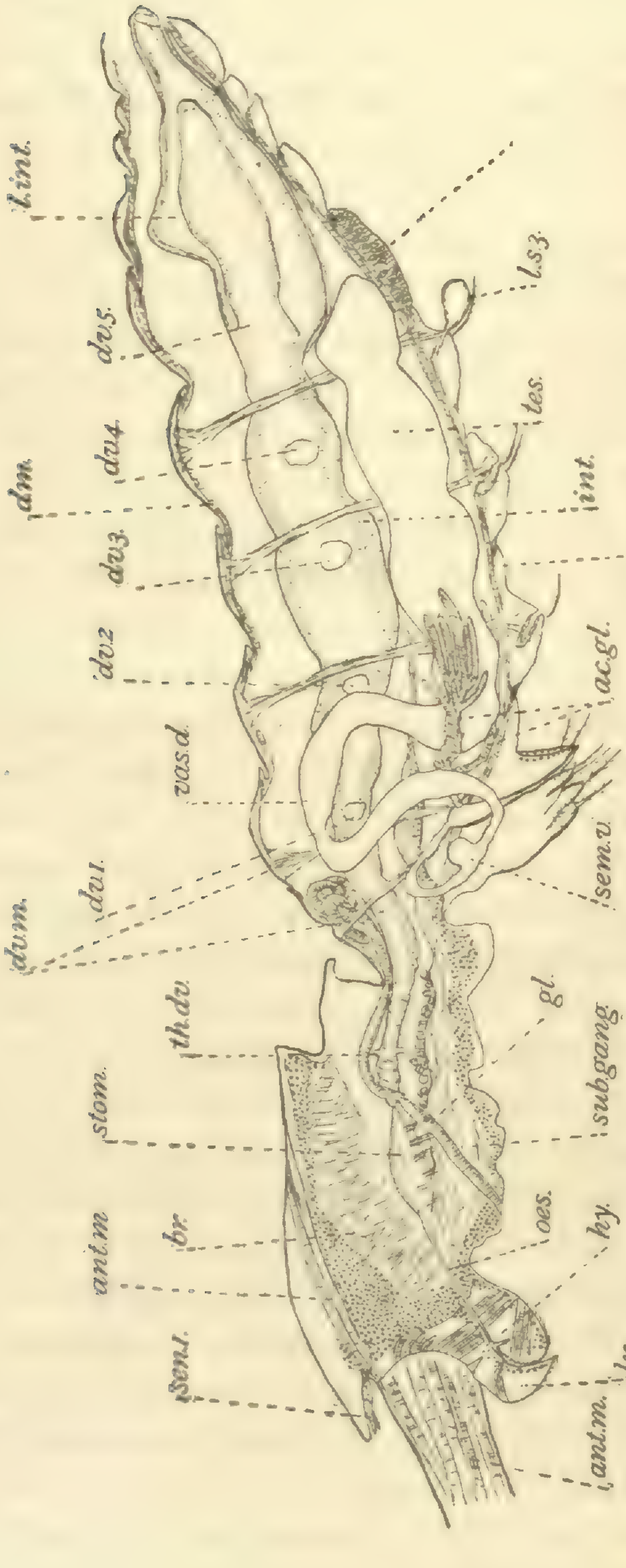


FIG. 6. — Diagrammatic sagittal section of the male of *K. wheeleri*. Lettering the same as in Fig. 5. *ant.m.*, muscles of chelicerae; *tes.*, testis; *vas.d.*, vas deferens; *ac.gl.*, accessory glands; *sem.v.*, seminal vesicle; *dm.*, dorsal muscles; *vm.*, ventral muscles.

receptaculum seminis of small crustacea." In all of my sections I have never been able to see any sign of spermatozoa in the vesicle, which is always full of a non-granular, gelatinous secretion. Just posterior to the outlet of the oviducts, and between the two lateral appendages of this region, is the outlet of the small flask-shaped receptaculum seminis. The accessory glands are small and insignificant, and in the lateral anterior portion of the abdomen they empty into the vagina. The ovary, which fills almost the entire lower portion of the abdomen, does not show its primitive paired condition. Although the muscular walls of the pouch-like ovary are bulged out with what appear to be cells, only a few of these become the eggs, while the remaining seem to be the nurse cells, and are consumed by the growing ova, which early in the spring lie in the upper portion of the organ. Later in the season a few of the eggs fill the entire ovary, while most of the small bodies have disappeared, and in their place a few oil drops remain. These oil drops are seen at this stage in the lumen of the oviducts. Fig. 5 is, for the most part, a diagrammatic sagittal section through a female Kœnenia. The ovary, however, is an exact camera drawing which shows the proportion between the true eggs and the food bodies, and their corresponding position in the ovary of an animal taken early in the spring. In Kœnenia the egg is evidently not fertilized until it reaches the vagina, and all the food that it receives before its fertilization is a product of the ovary and oviduct. The latter must also necessarily furnish the membrane of the egg. Just as there is a pair of dorso-ventral muscles for each pair of lung sacs, there is also a corresponding pair for the reproductive appendages of each segment. These, together with special muscles, undoubtedly cause a slight protrusion and retraction of these organs.

In the male the primitive paired condition of the generative organs is retained. The testes consist of two equally swollen tubes, beginning in the seventh or eighth segment and extending along the floor of the abdomen, to be continued anteriorly into the vas deferens of each side. The vasa deferentia are very much coiled, and fill — at certain times of the year — all

the space in segments two and three of the abdomen, before descending on each side to swell and form the seminal vesicles. From these vesicles the ducts run slightly up and back to a common opening situated between the points of attachment of the two pairs of the dorso-ventral muscles of these appendages. The accessory glands, which are larger in the male than in the female, appear to open into the atrium at a point just posterior to the orifice of the vasa deferentia. The exact courses of the vasa deferentia and the accessory glands are extremely difficult to follow. In places the walls of the ducts entirely disappear, leaving only as a guide, in the case of the vasa deferentia, the contained spermatophores. In some specimens the whole anterior portion of the abdomen is packed with spermatophores. Fig. 6 is a diagrammatic drawing of a longitudinal section through a male Kœnenia, taken to one side of the sagittal plane. Only the testis and vas deferens, with the accompanying accessory glands of one side, are shown. There are, evidently, delicate muscles in the walls of the testes. In the posterior ends of the testes are numerous cells which are undoubtedly sperm mother-cells, while the anterior portion appears to be crowded with small dotted packets. These dots, which must necessarily be the spermatozoa, glisten under transmitted light and rarely show a stain, even with iron-hæmatoxylin. Nowhere throughout the whole course of these organs is there any trace of spermatozoa possessing flagella. It must be that, in Kœnenia, the condition is retained which is found in most crustacea, which possess non-motal spermatozoa often imbedded in gelatinous spermatophores. It is probably due to this spermatophore secretion that the sperm cells almost entirely refuse to take on the stain.

UNIVERSITY OF TEXAS, AUSTIN, TEXAS,
May 23, 1901.

THE MAMMALS COLLECTED IN SAN MIGUEL ISLAND, PANAMA, BY W. W. BROWN, JR.

OUTRAM BANGS.

In the spring of 1900 Mr. W. W. Brown, Jr, made a short collecting trip to San Miguel Island, the largest of the islands in the Bay of Panama, known as the Archipelago de las Perlas. Here he stayed for nearly a month, — middle of April to middle of May, — and in this time secured, he believes, representatives of all the species of land mammals that occur on the island, with the possible exception of some bats.

San Miguel Island is about fifteen miles in length and lies twenty miles distant from the nearest point on the mainland, and sixty miles from Panama. It is composed of low-lying hills clothed in heavy tropical forest, hot, damp, and unhealthy.

The collection of birds made on this trip has already been reported upon.[1] The birds of the island are for the most part like those of the adjacent mainland, and five species only were considered different enough to receive distinctive names. Most of the mammals, on the other hand, seem to be well differentiated island species. I am much indebted to Gerrit S. Miller, Jr., for identifying the bats for me, and to Dr. J. A. Allen for comparing the large opossum with the various forms he has lately described from different parts of northern South America.

One hundred and fifty-seven mammals, belonging to twelve species, were collected by Mr. Brown in San Miguel Island, as follows:

Marmosa fulviventer nob.	4 specimens
Didelphis karkinophaga caucæ Allen . .	2 "

[1] Bangs, Outram. Birds of San Miguel Island, Panama. *Auk*, vol. xviii (January, 1901), No. 1, pp. 24–32.

Bangs, Outram. A New Honey Creeper from San Miguel Island, Panama, *Proc. New Eng. Zoöl. Club*, vol. ii (Feb. 8, 1901), pp. 51, 52.

Lepus incitatus nob.	1 specimen
Dasyprocta callida nob.	6 specimens
Loncheres labilis nob.	19 "
Proechimys burrus nob.	51 "
Zygodontomys seorsus nob.	68 "
Mus musculus Linn.	1 specimen
Mus rattus rattus Linn.	1 "
Mus rattus alexandrinus (Geoff.)	1 "
Vampyrops helleri Peters	1 "
Hemiderma brevicaudum (Wied.)	1 "

Marmosa fulviventer sp. nov.

Four specimens, taken between April 28 and May 8.

Type: No. 8435, adult ♂, Bangs Collection, Museum of Comparative Zoölogy, collected April 28, 1900.

Characters: Nearest to the form of the *Marmosa murina* series from the Santa Marta region of Colombia, — *M. mitis* Bangs. Differing in being smaller; ear smaller; fur shorter, harsher, less silky; color, above more fulvous, less olivaceous, brown; under parts wholly fulvous, darkest on the sides (in *M. mitis* the under parts are yellowish-white); skull similar.

Color: The usual black facial markings, rest of upper parts between cinnamon and tawny-ochraceous; upper surface of arms, sides of neck, and sides, much brighter, more ochraceous-rufous; under parts strong buff, shading into ochraceous-buff on lower sides and on under surfaces of arms and legs, the fur unicolor except on lower sides, where it is pale gray basally; tail dusky, paler below than above; feet and hands dull grayish-white.

MEASUREMENTS.

NUMBER.	SEX.	TOTAL LENGTH.	TAIL VERTEBRÆ.	HIND FOOT.	EAR FROM NOTCH.
8435	♂ adult type	330	175	24	22
8436	♀ " topotype	325	180	23	22
8437	♀ " "	340	175	25	20
8438	♂ old adult topotype	head & body, 170		23	22

Skull, type, adult ♂, basal length, 34.4 ; occipito-nasal length, 37.4 ; zygomatic width, 20.4 ; least interorbital width, 6.2 ; length of nasals, 17.6 ; width of nasals, 5 ; length of palate, 18.8 ; upper tooth row, from front of canine to back of last molar, 15.2 ; length of single half of mandible, 27.8.

Didelphis karkinophaga caucæ Allen.

Two specimens, ♂ and ♀, were taken May 8. These have been compared by Dr. J. A. Allen with extensive material from South and Central America ; and it is Dr. Allen's opinion that they are best referred to this form, though they do not represent it in its extremes.

Lepus (Tapeti) incitatus[1] sp. nov.

Type (and only specimen) : No. 8441, old adult ♀, Bangs Collection, Museum of Comparative Zoölogy. Collected April 30, 1900.

Characters : An island form of *Lepus gabbi* Allen. Distinguished by its larger size, paler, more reddish-brown coloring, and larger, heavier skull, with much heavier, more arched rostrum.

Color: Upper parts tawny-ferruginous ; brightest on top of head, palest — shading to dull ochraceous — on sides ; middle of back and top of head varied by the admixture of black-tipped hairs; nuchal patch, arms, and outer surface of legs clear, bright, tawny-ferruginous ; superciliary stripe dull buffy-white ; outer surface of ear colored like back, with short, dusky tip and narrow, yellowish-white outer border, inside of ear very sparsely haired — the hairs colorless ; under parts soiled white, except underside of neck, which is Isabella-color, shading into dull, tawny-ferruginous on sides of neck.

Skull: Compared with skulls of true *L. gabbi* from Panama and Chiriqui, the skull of *L. incitatus* is larger and heavier throughout ; rostrum much wider and heavier, and more rounded and arched ; bony palate wider and longer ; molar and incisor teeth heavier.

[1] *Incitatus :* swiftly running ; rapid, quick.

Measurements: Type, old adult ♀, total length, 420; tail vertebræ, 20; hind foot (with claw), 80; ear from notch, 45.[1]

A. Type of *Lepus incitatus*, adult ♀.
B. *Lepus gabbi* from Loma del Leon, Panama, adult ♀.

Skull, type, old adult ♀, basal length, 57; occipito-nasal length, 74.6; zygomatic width, 35.4; mastoid width, 23.8; least interorbital width, 16.2; length of nasals, 30.4; width of nasals, 13; length of palatal bridge (from incisive foramina to

[1] Specimens of true *L. gabbi* taken by Mr. Brown at Loma del Leon, Panama, and Divala, Chiriqui, measured as follows:

Number.	Sex.	Locality.	Total Length.	Tail Vertebræ.	Hind Foot (Claw).	Ear from Notch.
8424	♀	Loma del Leon	340	18	78	38
8425	♀	"	345	20	75	45
10065	♂	Divala	370	20	77	47
10066	♀	"	355	15	75	48
10067	♀	"	370	18	78	50

palatal notch), 9 ; length of incisive foramina, 17 ; width of incisive foramina, 6.4 ; upper tooth row, alveola, 14.6 ; length of single half of mandible, 56 ; lower tooth row, alveola, 15.4.

Remarks. — The hare was not at all common in San Miguel Island, and Mr. Brown saw but one other during his stay. Mr. Brown tells me that *Lepus gabbi* and *L. incitatus* are extraordinarily swift of foot and are seldom seen except for an instant as they dart like a flash through the undergrowth.

The form found in San Miguel Island differs from true *Lepus gabbi* of the Isthmus in its larger size and heavier, slightly different skull. The color is also slightly different, the island race being less marked along the back with black-tipped hairs, and the general coloring is decidedly redder.

Dasyprocta callida[1] sp. nov.

Six specimens, April and May.

Type: No. 8443, adult ♂, Bangs Collection, Museum of Comparative Zoölogy. Collected May 8, 1900.

Characters: A well-marked island species of the *variegata-isthmica* group. Color pale yellowish ; rump hairs black, with white tips. Skull very slender, with long, light rostrum and narrow nasals. Molar-form teeth small.

From *D. isthmica*, the new species can be told by its white-tipped rump hairs (yellow-tipped in isthmica), and from *D. colombiana* (the form of this group inhabiting the Santa Marta region of Colombia), which also has white-tipped rump hairs, by much paler and more yellowish coloration. From either it is easily known by its very different skull (see figure on next page).

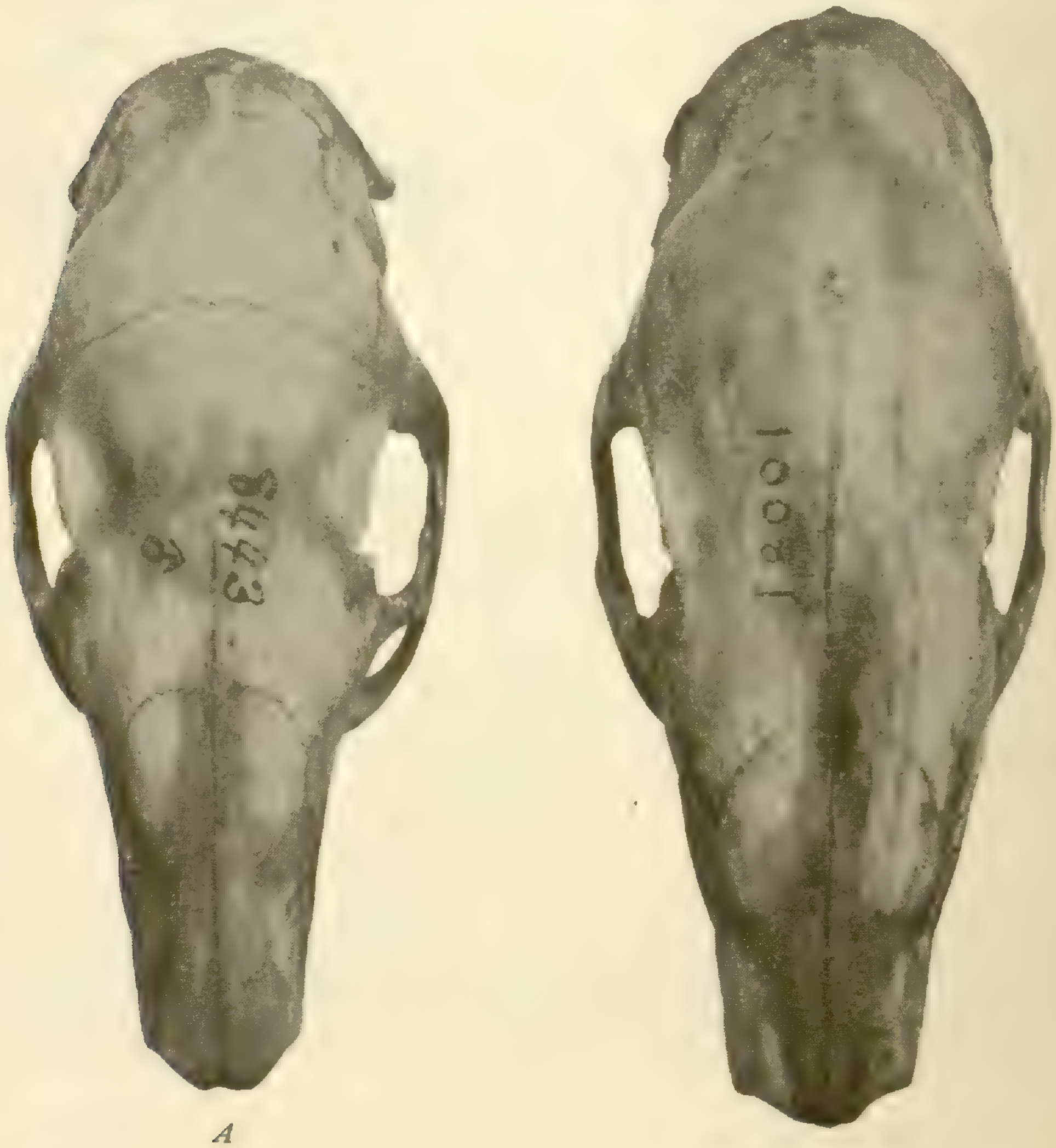
From the Central American *D. punctata*, *D. callida* and its allies differ chiefly in the character of the hairs of the rump. In *D. punctata* these are not so elongated and are annulated and colored like the hairs of the rest of the upper parts.

Color: Hairs of upper parts annulated with yellowish and black, giving a slightly variegated look, though the yellowish much predominates, and the general color is yellowish clay-color, brighter, more ochraceous in middle of back anterior to

[1] *Callidus* : that is, taught wisdom by experience ; shrewd, cunning.

rump ; rump hairs elongate, black with white tips ; under parts soiled white, the hairs annulated with drab ; feet and hands brownish-black.

The type and No. 8447 are in fresh pelage and are similar. No. 8445, adult ♂, is rather darker and more nearly approaches *D. colombiana* in color. The three other specimens, of which



A *B*

A. *Dasyprocta isthmica* from Divala, Chiriqui, adult ♀.
B. Type of *Dasyprocta callida*, adult ♂.

two are nursing females, are in worn, shabby pelage, in which the black of the rump has faded to dull brown and the white tips of the hairs are worn down and discolored. In No. 8446, new, normally colored rump hairs are growing in again among the old faded ones.

Skull: The skull of *D. callida* is very distinctive, and can at once be told from that of any of its allies by its slenderness, its long, narrow rostrum and long, narrow nasals. The molar-form teeth are very small.

Measurements.

Number.	Sex.	Date.	Total Length.	Tail Vertebræ.	Hind Foot.	Ear from Notch.
8443, type	♂ adult	May 8	480	25	102	38
8444, topotype	♀ "	April 22	460	22	100	38
8445, "	♂ "	" 21	465	22	102	37
8446, "	♀ "	" 21	510	30	105	38
8442, "	♀ "	" 26	485	20	97	35
8447, "	♂ youngish	" 25	420	20	96	33

Note. — All external measurements are the collector's. Hind foot is measured *with* the claw.

Skull, basal length, 85.4 ; occipito-nasal length, 98.6 ; zygomatic width, 44 ; mastoid width, 32 : least interorbital width, 26.2; length of nasals, 38 ; width of nasals, 15.4 ; length of palate, to palatal notch, 39 ; to end of pterygoid, 55.4 ; upper tooth row (with four molar-form teeth in place), 17.2 ; greatest width of rostrum, 24 ; length of single half of mandible, 58 ; lower tooth row (with four molar-form teeth in place), 18.8.

Remarks. — The six specimens were all shot by Mr. Brown among mangroves, the leaves of which they are very fond of. The animal is much hunted by the negro pearl divers, and is exceedingly shy and wary, and for some time Mr. Brown was unable to secure one. One day during a storm he noticed that when a mangrove blew over it was at once stripped of its leaves by the agoutis. Acting upon a plan that this habit of the animal suggested to him, he took several large stones with him, and concealed himself in a tree. After a little he sent a stone crashing through the mangroves and presently saw an agouti cautiously approach the spot, thinking a mangrove had fallen over. The first day he shot two specimens in this way, and afterwards four more.

Loncheres labilis[1] sp. nov.

Nineteen specimens, April and May.

Type: No. 8480, old adult ♂, Bangs Collection, Museum of Comparative Zoölogy. Collected April 26, 1900.

Characters: Most nearly related to *L. caniceps* Günther of Medellin, Colombia. Pelage long and stiff, but *without spines.* Judged by description alone, the new species is brighter and redder in color and its head is not gray. The skull compared with Günther's figures (*P. Z. S.*, 1876, p. 746) is more slender, the palate and post-palatal regions are narrower, and in profile the skull of the island animal is much flatter, the supraorbital ridge not rising in a curve but lying flat and straight.

Type of *Loncheres labilis*, adult ♂ (three views).

Color and Pelage: Pelage moderately long and harsh, but *wholly without spines.* Whiskers very long, black, as also a patch of whisker-like hairs behind the eye and others in front of and on edge of ear. Top of head, nose, and cheeks black, the hairs somewhat annulated with yellowish, giving a pepper-and-salt appearance; yellowish-white patches at base of whiskers, above eye, and behind ear; rest of upper parts bright ferruginous, varied by black-tipped hairs along middle of back, varying in amount in different individuals, — some specimens

[1] *Labilis*, gliding, slipping.

being wholly of an intense ferruginous color from nape to tail, others having the rump only ferruginous, the rest of back being darkened by a copious sprinkling of black-tipped hairs; chin dull grayish-white; rest of under parts varying from strong buff to clear ferruginous, some examples having both colors irregularly distributed in patches; upper surfaces of hands and feet yellowish-brown; nails white; tail colored like the body for a short distance, then black, sometimes yellowish-white at tip, thickly clothed with stiff hairs, which, however, do not hide the scales (except at base, where the tail is colored like the body); ears blackish, small and low, nearly naked except for the long black whisker-like hairs that surmount their edges.

Skull: Compared with the figures of that of *L. canicaps*, the skull of *L. labilis* is much more slender, with narrower palatal and post-palatal regions; viewed in profile it is much flatter, with the supraorbital ridge lying flat and straight and not rising in a curve.

MEASUREMENTS.

NUMBER.	SEX.	DATE.	TOTAL LENGTH.	TAIL VERTEBRÆ.	HIND FOOT.	EAR FROM NOTCH.
8480, type	♂ adult	April 26	540	240	47	15
8468, topotype	♂ "	" 26	540	220	48	15
8471, "	♂ "	" 26	540	220	47	15
8470, "	♂ "	" 26	535	260	48	16
8469, "	♂ "	" 26	530	210	48	15
8473, "	♂ "	" 21	500	240	45	15
8474, "	♂ "	" 23	470	220	47	15
8472, "	♂ "	" 26	470	230	45	16
8475, "	♂ young	" 24	440	215	45	14
8477, "	♂ "	May 4	420	175	42	15
8476, "	♂ "	" 5	420	195	42	14

Skull, type, adult ♂, basal length, 47.8; occipito-nasal length, 56.6; zygomatic width, 27.4; mastoid width, 22.4; least inter-orbital width, 12; length of nasals, 16; width of nasals, 7.2; length of palate, to palatal notch, 21.2; to end of pterygoid, 36.4; upper tooth row, 13; length of single half of mandible, 34; lower tooth row, 13.2.[1]

[1] Some skulls that appear to be of about the same age are smaller, others larger.

Remarks. — This island species of Loncheres belongs to a group quite different from either true Loncheres or Isothrix. The skull is, in important characters, similar to that of true Loncheres, but the pelage is very different in wholly lacking spines. Isothrix has still softer pelage and more hairy tail, and also a different skull. I hope some mammalogist, with more material at his command than I now have, will before long readjust and properly divide the different groups of this series of "spiny rats."

Loncheres labilis was abundant in San Miguel Island, but was wholly arboreal, Mr. Brown catching all his specimens in traps set on the branches of large trees. It appears to be diurnal, and on one or two occasions Mr. Brown saw the animal proceeding along the branches with a curious gliding gait, his account suggesting the name I have used for the species. It is the "Raton Marenero" of the islanders.

Proechimys burrus[1] sp. nov.

Fifty-one specimens, April and May.

Type: No. 8458, adult ♂, Bangs Collection, Museum of Comparative Zoölogy. Collected April 30, 1900.

Characters: A large, bright-colored, insular form of the *Proechimys centralis* series. Differing from its nearest mainland ally, *P. centralis panamensis* Thomas, by its larger size and richer red color.

From *P. centralis chiriquinus* Thomas it differs in less spiny back and redder colors. In color it is nearest to *P. centralis centralis* (Thomas), but its feet are much darker.

The skull is slightly different from that of any of the other subspecies. The rostrum is heavier, even, than in *chiriquinus*. The nasals are long, broad, and bluntly truncate posteriorly. (In *centralis* and *panamensis* the nasals are pointed posteriorly, and in *chiriquinus* they are shorter and less bluntly truncate.) Hamular process broad and spatulate, as in the other subspecies. Palatal foramina shorter than in *chiriquinus*, and less parallel-sided and wider open than in *centralis* and *panamensis*.

[1] *Burrus*, red, rufous.

Color and Pelage: Spines confined to anterior two-thirds of back (as in all members of this group of the genus); spines not particularly numerous (as is the case in *chiriquinus*), but well covered by the hair; whole upper parts rich, deep, ferruginous, slightly varied along back by the brownish-black tips of the spines showing through the hair; top of nose, cheeks, and lower sides a little paler, more yellowish; under parts pure white, except anal region and base of tail, which are colored like the back; hands and feet dusky brown, in some specimens slightly grayer along inner edge of metatarsus; tail bicolored, black above, grayish below, well clothed with short, stiff hairs; ears dusky, nearly naked.

Type of *Prechimys burrus*, adult ♂.

Young examples, half grown, are much darker, less reddish above; but among the adults there is little variation in color.

Measurements.

Number.	Sex.	Date.	Total Length.	Tail Vertebræ.	Hind Foot	Ear from Notch
8458, type	♂ adult	April 30	470	185	58	22
8448, topotype	♂ "	" 21	490	205	60	22
8455, "	♂ "	" 23	470	165	54	22
8449, "	♂ "	" 24	470	165	58	21
8451, "	♂ "	" 22	460	180	58	21
8450, "	♂ "	" 27	440	160	58	22
8459, "	♀ "	" 21	425	150	52	20
8454, "	♂ "	" 21	438	165	52	22
8456, "	♀ "	" 24	410	145	50	20
8460, "	♂ "	May 5	400	140	52	20

Skull, type, adult ♂, basal length, 52; occipito-nasal length, 61.2; zygomatic width, 29; mastoid width, 22.2; least interorbital width, 13.4; length of nasals, 24.2; width of nasals,

7.6; length of palate to palatal notch, 21; to end of pterygoid, 34; length of palatal foramina, 5.2; width of palatal foramina, 3; upper tooth row, 9.8; length of single half of mandible, 33.8; lower tooth row, 10.2.

Remarks. — The San Miguel spiny rat is a slightly differentiated island form of the *centralis* series. It was very common in the island, and Mr. Brown easily took as many specimens as he wanted. It is known to the islanders as "Raton mockungay." They, however, believe the tailless individuals are a different animal. About one-third of the specimens taken were tailless. The animal was generally distributed throughout the island, and was often found living in the huts and sheds of the negroes, like the common rat.

Mr. Brown took *P. panamensis* at Loma del Leon, Panama, and *P. chiriquinus* at Divala, Chiriqui.

Zygodontomys seorsus[1] sp. nov.

Sixty-eight specimens, April and May.

Type: No. 8490, old adult ♂, Bangs Collection, Museum of Comparative Zoölogy. Collected May 5, 1900.

Characters: Similar in color and general appearance to *Z. brevicauda* (Allen and Chapman) of Trinidad, but much larger, hind foot much bigger, tail less distinctly bicolored and more coarsely scaly. Skull larger, rougher, supraorbital heading heavier, transverse ridge where squamosal and supraoccipital meet more pronounced, forward end of zygoma and zygomatic plate standing farther out from skull.

From *Z. brunneus* Thomas, *Z. seorsus* differs by its larger size, larger foot, and richer, more reddish coloration.

Color and Pelage: Upper parts russet-brown, shaded with dull ferruginous, the latter color more intense on the rump; whole dorsal region thickly set with brownish-black-tipped hairs; sides paler, more yellowish; under parts dull buffy-gray, strongly shaded with dull ferruginous in anal region; line of demarcation between colors of upper and under parts indistinct; upper surfaces of hands and feet yellowish-brown;

[1] *Seorsus*, isolated, living apart.

soles naked ; ears sparsely haired, dusky ; tail very sparsely haired, coarsely scaly, indistinctly bicolored, blackish, rather paler towards base below.

Young examples are rather darker, less reddish, brown above, and the upper surfaces of feet and hands darker brown, less yellowish.

The adults vary but little in color ; some specimens are yellower above and others more strongly ferruginous.

MEASUREMENTS.

NUMBER.	SEX.	DATE.	TOTAL LENGTH.	TAIL VERTEBRÆ.	HIND FOOT.	EAR FROM NOTCH.
8490, type	♂ adult	May 5	320	140	34	18
8485, topotype	♂ "	" 4	315	140	34	17
8492, "	♀ "	April 23	310	130	32	17
8495, "	♂ "	" 25	305	125	33	17
8487, "	♂ "	May 2	300	120	30	17
8486, "	♂ "	April 25	295	125	32	17
8496, "	♂ "	May 6	295	120	32	17
8497, "	♀ "	" 8	290	125	31	16
8483, "	♀ "	April 30	290	125	30	18
8484, "	♂ "	" 21	290	118	30	18
8489, "	♂ "	May 5	285	120	30	15
8488, "	♂ "	" 3	285	120	30	16
8481, "	♀ "	April 26	285	110	30	16
8491, "	♂ "	" 25	280	120	30	17
8493, "	♂ "	" 22	275	110	30	17

Skull, type, old adult ♂, basal length, 32.8 ; occipito-nasal length, 35.2 ; zygomatic width, 18.4 ; mastoid width, 12.8 ; length of nasals, 15 ; width of nasals, 4.4 ; least interorbital width, 5.4 ; width across zygomatic plates, 11.2 ; length of incisive foramina, 7.4 ; width of incisive foramina, 3.2 ; length of palate, to palatal notch, 16 ; to end of pterygoid, 22 ; upper tooth row, 5 2 ; length of single half of mandible, 21 ; lower tooth row, 5.2.

Remarks. — The San Miguel vesper rat is a strongly marked island species, most nearly related to *Z. brevicauda*, of Trinidad, which it precisely resembles in color and character of pelage. Its much greater size, bigger foot, and different tail distinguish

it, externally, from the Trinidad species, and the skulls of the two can easily be distinguished.

Z. seorsus was an abundant animal in San Miguel Island, inhabiting the dense, swampy woods, and Mr. Brown found no difficulty in trapping it in numbers.

That the vesper rat of San Miguel Island should be so like the Trinidad species is interesting, especially so as the yellow honey creeper of the island (*Cœreba cerinoclunis* Bangs) is much more nearly related to *C. luteola* of Venezuela, Trinidad, and northeastern Colombia than to *C. mexicana* of the neighboring coasts of Panama and Colombia.

Mus musculus Linn.

One adult ♂, taken April 20, 1900.

Mus rattus rattus Linn.

One adult ♂, taken April 20, 1900.

Mus rattus alexandrinus (Geoff.).

One adult ♂, taken April 23, 1900.

The three introduced species of Mus could not have been very numerous in San Miguel, as one individual of each was all that fell into Mr. Brown's traps in over three weeks of collecting.

Vampyrops helleri Peters.

One adult ♀, taken April 25, 1900.

Mr. Gerrit S. Miller, Jr., tells me that this is the only example of this rare bat that he has seen, but the specimen agrees so perfectly with the description that he has little doubt of its being true *V. helleri*.

Hemiderma brevicaudum (Wied.).

One adult ♂, taken April 25.

SOME PROTOZOA OF ESPECIAL INTEREST FROM VAN CORTLANDT PARK, NEW YORK.

GARY N. CALKINS.

Biologists in the vicinity of New York are particularly fortunate in having in Van Cortlandt Park a pond which yields a great variety of interesting forms belonging to the lowest classes of animal life. For the casual passer-by the pond is an unsightly spot, but the green scum which covers parts of its surface, and the healthy water-plants around its edges indicate to the microscopist a rich fauna.

Van Cortlandt Park is about nine miles from the Grand Central Station at Forty-second Street, New York, and is reached by way of the Putnam Division of the New York Central Railroad. The trains on this division leave New York at the terminal of the Elevated Railroad at Eighth Avenue and One Hundred and Fifty-fifth Street at least twice each hour, and from this point Van Cortlandt is only four miles. The pond lies in front of the station at Van Cortlandt, extending away to the northeast. Following the railroad up to the northern end of the pond, beyond the spot where an offshoot of the pond passes below the track to the left, a thick bed of lily pads on the right indicates the spot where *Amœba proteus* can be invariably found. A quantity of the superficial slime covering the bottom should be scooped up in a Mason jar, or other collecting jar which has been used only for living things, and with a small amount of water carried back to the laboratory. Immediate examination shows isolated forms of different genera of Protozoa, which will be seen again later in considerable numbers. Among these will be an occasional Amœba, Actinosphærium, Stentor, etc., — forms commonly found in similar pond water. If the material be emptied into flat dishes about 2″ deep and 12″ to 15″ in diameter, and covered with about an inch and a half of tap water, the majority of the forms originally

observed will disappear within a few days, the tap water apparently not agreeing with them. Examination of the material from time to time during the ensuing month, however, shows the gradual return of the original organisms, and with this return the animals are much more numerous than before, and with the advantage that only one type of organism appears to occupy the stage at a time. *Amœba proteus* comes along from four to six weeks after collection, and so constant is this appearance that I can plan in September for my classes in November.

The addition of new tap water has a retarding effect upon the cultures, and a too rapid culture can be checked by this means. A slow culture, on the other hand, should be kept from evaporating and should not be replenished.

In the present contribution I wish to offer a few notes in regard to some forms of particular interest that have appeared during the year, — forms which, for the most part, are rarely observed and but little known. Among these are Nuclearia, Mastigamœba, Multicilia, Lacrymaria, and a species of Actinobolus. It may be of interest, however, to enumerate some of the other forms that are found every year in this water. Of the Rhizopoda there are four species of Amœba (not counting *A. radiosa*, the young form of *A. proteus*); two species of Pelomyxa, three of Difflugia, one of Centropyxis, Arcella, and Euglypha; and of the Heliozoa, Actinophrys, Actinosphærium, Acanthocystis, Pinacocystis, and the dainty stalked Clathrulina are frequently found. Of the Mastigophora there are several species of Euglena, Phacus, Astasia, Trachelomonas, Peranema, Chilomonas, Cryptomonas, Petalomonas; the beautiful colony form Poteriodendron, and the more common colonies Volvox, Pandorina, Eudorina, Gonium, and Synura. The minute choanoflagellates Monosiga and Codosiga, and the dinoflagellates Peridinium and Glenodinium, with their actively vibrating transverse flagella, occur in greater or less abundance. The more common forms of Ciliata in the pond are: Paramœcium, Dileptus, Bursaria, Stentor, Spirostomum, Enchelys, Chilodon, Prorodon, Coleps, Urocentrum, Loxophyllum, Loxodes, Colpoda, Cœnomorpha, Gastrostyla, Urostyla, Euplotes, Kerona, Trichodina

(the last two parasites on *Hydra fusca*), Vorticella, Zoöthamnium, Epistylis. Finally, the Suctoria are represented by the two genera Sphærophrya and Podophrya.

Turning now to the less frequently observed forms, there is, in some cases, apart from the fact that they may be found at Van Cortlandt, little to be said in addition to the existing well-known descriptions. A few remarks as to their mode of life and relationships, however, may not be out of place.

Nuclearia delicatula Cienk.

This form, which was first described by Cienkowsky, has occupied rather a varied position in classification. Placed by some writers with the Heliozoa, by others with the Rhizopoda, it belongs to those forms which, in any artificial classification, must be considered as individuals rather than in groups. The peculiarity of Nuclearia lies in the fact that its pseudopodia, while long and needle-like, and in this respect similar to those of the Heliozoa and the Radiolaria, are at the same time very changeable, like those of the Rhizopoda. When the needle-form pseudopodia are drawn in, the organism moves along like an Amœba and changes its place much more rapidly than the majority of the Heliozoa. When not moving, the animal thrusts out its fine ray-like pseudopodia to a distance equal to one and a half times its body diameter. The animal is restless, however, and retains this condition only a short time, moving off soon with an elongate form and by means of its amœboid processes. Unlike the fine ray-like pseudopodia of the common Heliozoa, the appendages of this form have no axial filaments to give them rigidity, and they frequently branch and sub-branch, while the animal is moving (Fig. 1, *B*). In this condition it surrounds and ingests food particles of various kinds, especially plant cells, euglenoids, etc. I had a very good culture of Nuclearia last year, and had studied the little organism rather carefully for several days, devoting many hours to their mode of life, etc., but I had not seen one divide. One day I had a very fine specimen under an immersion lens, when a colleague, who was born under a lucky star, came in. He had not watched the specimen five minutes before he

remarked, "This specimen is beginning to divide." He was generous enough, however, to give me several views of the animal during the process, which lasted only less than a minute

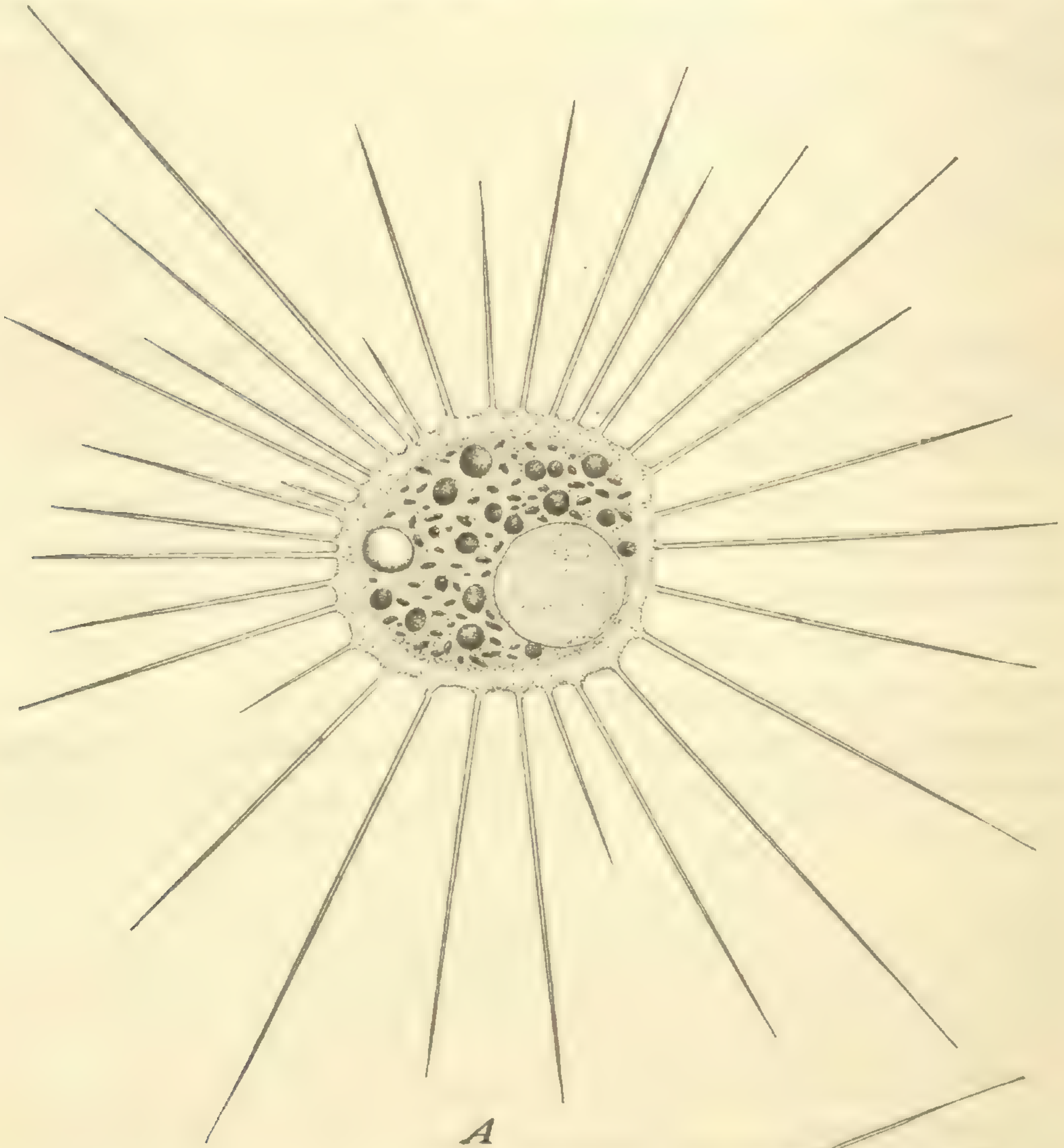


FIG. 1. — *Nuclearia delicatula* Cienk. *A*, the heliozoan condition with ray-like pseudopodia; *B*, the motile amœboid condition. × 1200.

and was not unlike the cleavage of a sea-urchin egg. After division the daughter-individuals moved apart with the characteristic amœboid motion.

It is not an easy matter to interpret Nuclearia, for it may be regarded as a degenerate heliozoan which has lost its axial filaments, or as a primitive form which has never had these peculiar axial structures. The interpretation involves the old dispute over the most primitive forms of Protozoa. Are we, with Klebs, to hold that the flagellates were the most primitive forms ; or with Lankester, that the rhizopods are to be so considered ; or with Bütschli, that the flagellated amœboid forms were the ancestors of both rhizopods and flagellates? The problem, to my mind, has no great importance, for it is quite probable that the Protozoa have not come down without change from that unknown period of the primitive animal forms, while even in historic times they may have been adapted and readapted many times over to changing conditions of environment. The fact that the majority of Rhizopoda have flagellated swarm-spores is not sufficient proof that their ancestors were flagellated, while on the other hand the frequent amœboid condition of the flagellates is equally valid evidence that the rhizopod form was the older. Flagella and pseudopodia are not far removed from one another, and frequent observations have confirmed Dujardin's early view that flagella may become pseudopodia and pseudopodia flagella. The transitional forms such as Dimorpha, Actinomonas, etc., only strengthen the connection, and it will be shown, I believe, that many of the pseudopodia of Heliozoa are similar to the flagella of the Mastigophora. Blochmann has shown, for example, that in Dimorpha the pseudopodia have axial filaments, which, as in Actinophrys, focus in the nucleus or its vicinity. The flagellum, too, is focused at the same point, so that in Blochmann's figure the axial filaments and the flagellum appear to be the same in structure. Artodiscus, according to Pénard, is a heliozoön which dances about the field upon the tips of its ray-like pseudopodia. In this case the pseudopodia are like so many flagella, for there can be no doubt that the motion is due to the contraction and elasticity of the pseudopodia and probably of the axial filaments in them. Acanthocystis, also, has a slow, rolling motion, by means of which it covers a distance equal to twelve times its own diameter in one minute (Pénard). Here, also, although

less than in Artodiscus, the pseudopodia are probably contractile.

There thus appears to be some morphological ground in favor of the hypothesis that Rhizopoda may have originated from the Mastigophora and through the Heliozoa. Artodiscus and Acanthocystis may be regarded as having many flagella of modified form, while Dimorpha, which has a typical flagellate stage, has one true flagellum and at the same time pseudopodia of the heliozoan type. In Actinophrys, Sphærastrum, Heterophrys, etc., the contractile element, whatever it is, is lost, and the pseudopodia appear rigid and apparently serve no purpose in movement. They are of the same type, however, as in Artodiscus and Dimorpha, and, as in the latter, they center at a common point to form a system of rays very much like a centrosphere in Metazoa. In Actinosphærium the rays no longer focus in a common center, although each ends in the vicinity of some nucleus.

In respect of the axial filaments the Foraminifera apparently represent an intermediate stage between the Heliozoa and the fresh-water Rhizopoda. It has been frequently pointed out that the central portion of the pseudopodia of these forms is dense and stiff as compared with the outer plasm, which has the typical flowing motion of a rhizopod, thus reversing the conditions of one of the lobose forms.

If the relations as outlined above would hold good between the Heliozoa and the Mastigophora, then Nuclearia, having lost its axial filaments, finds its real position as an intermediate form between Heliozoa and fresh-water rhizopods, retaining, however, the fine and needle-like pseudopodia of the Heliozoa. Considered in this connection it would be a degenerate form. The entire argument, however, might work equally well the other way, and it might be held that an Amœba such as *A. radiosa*, or *A. tentaculata*, or Nuclearia, develops vibratile pseudopodia having an axial filament of especial contractile substance. The foraminiferan pseudopodia would be a first step in such a development, Acanthocystis, Artodiscus, and Dimorpha successive following steps, until a flagellate would be the outcome. It would be difficult only to place Actinophrys, Actinosphærium,

Heterophrys, Sphærastrum, etc., according to such an hypothesis. In either hypothesis Nuclearia would form an important intermediate link.

Mastigamœba verrucosa S. K.

A number of specimens of this interesting form appeared in one of my cultures during October, and I had a good opportunity to study it. The species is different from that described by F. E. Schultze (*Mastigamœba aspera*), and belongs apparently to that which Kent described as *M. verrucosa*, although in size and general form, etc., it agrees with the description of *Mastigamœba invertens* of Klebs. I could not make out, however, that the organism reverses its axes when it comes to rest, — a point upon which Klebs placed considerable importance.

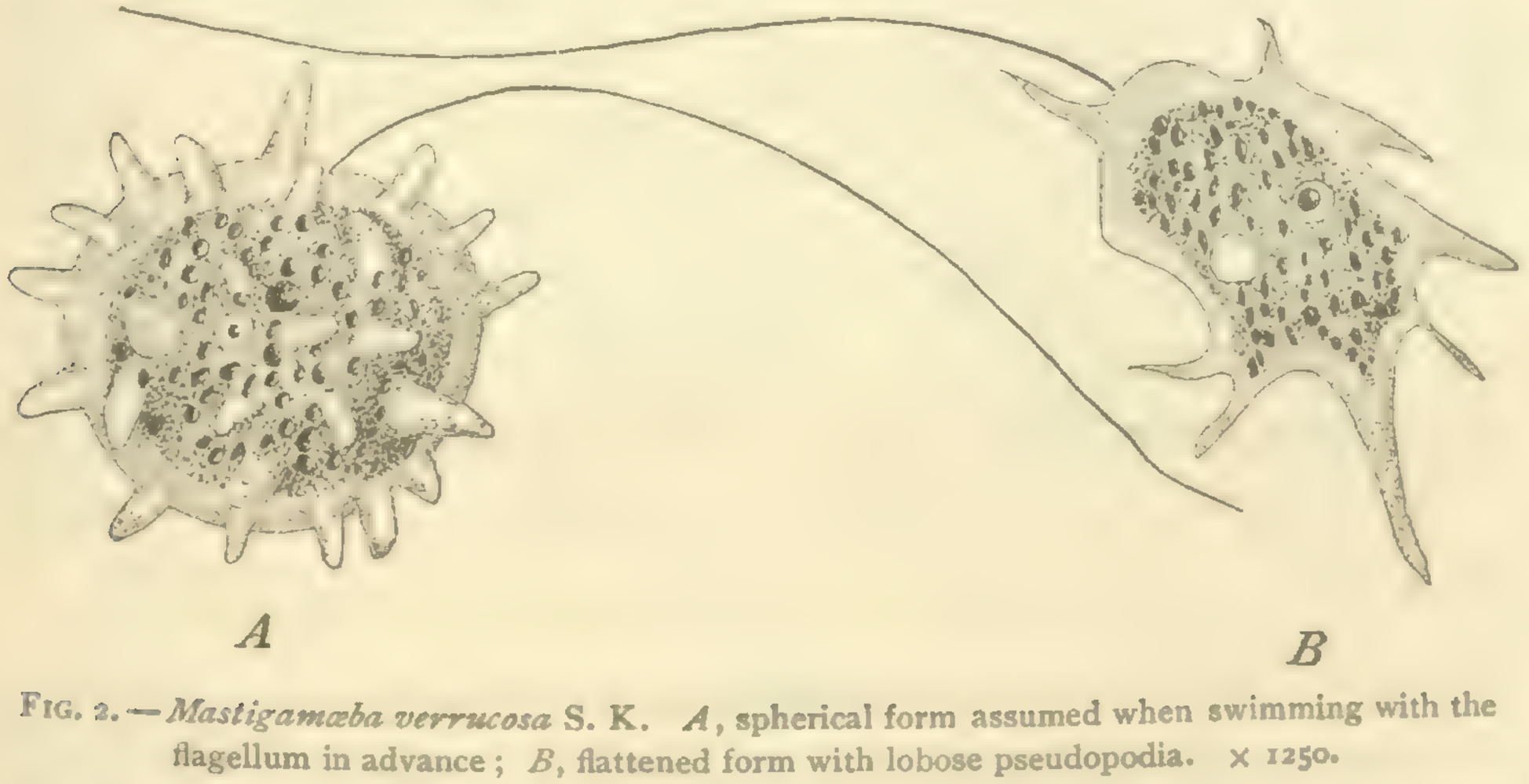


FIG. 2. — *Mastigamœba verrucosa* S. K. *A*, spherical form assumed when swimming with the flagellum in advance; *B*, flattened form with lobose pseudopodia. × 1250.

When first observed this species of Mastigamœba appears like a monad with an irregular outline, which makes its way through the water with a peculiar irregular course, vibrating the while as though shaken vigorously. The cause of the vibration is the action of the rather long flagellum, which is directed in advance. On all sides of the minute body are lobose processes of variable length (Fig. 2). After progressing in this way for some time it finally comes to rest and the pseudopodia are stretched out in all directions, like those of a small Amœba. The flagellum, in the mean time, vibrates slowly at one end. In its usual motile condition the organism is round, but when quiet and with outstretched

pseudopodia it assumes a flattened shape, and a distinct ectoplasm and endoplasm can be made out. After a shorter or longer period of rest the action of the flagellum becomes more and more rapid, the body becomes detached from the substratum and assumes a spherical form, after which it again moves through the water with the peculiar vibrating motion which first attracted my attention. A minute contractile vacuole pulsates at irregular intervals and cannot be made out easily when the organism is moving. A small spherical nucleus lies near the base of the flagellum, but no structure could be made out.

In the resting condition the pseudopodia surround and take into the body small objects of different kinds, which are stored up in the endoplasm until digested. The process is apparently no different from that in *Amœba proteus*.

Mastigamœba belongs to a group of flagellated amœboid forms, the Rhizomastigidæ which Bütschli regarded as ancestral to both flagellates and rhizopods. Klebs, on the other hand, placed the beginnings of both groups farther back, and considered the Rhizomastigidæ as flagellates which have become amœboid.

Multicilia

Only one individual of this interesting genus was seen, and no details were made out save the presence of about twenty long flagella-like cilia distributed evenly about the body. By means of these appendages the organism moved along with a rolling motion.

The search for the beginnings of the ciliate stem from some more generalized organisms has been singularly vain. The conservative structure which the infusorian body presents gives but little clue to their ancestry. In only one other known case (Polykrikos among the Dinoflagellidia) is there a similar nuclear dimorphism, while the almost universal reproduction by transverse division is met with among the Mastigophora but rarely. It is generally conceded that the infusorian stem must have arisen from the flagellate stem at an early period, and must have become progressively differentiated until the present

striking peculiarities were well established. It is assumed by Bütschli and by the majority of others who adopt the hypothesis that the ciliates were derived from the Mastigophora, that the original forms may have been similar to the present genus Multicilia, whose motile organs are more like flagella than they are like cilia. There is no close connection between the cilia and flagella, as there is between the latter and pseudopodia, but Bütschli holds that the Ciliata might have been derived from such a form as Multicilia, in which the motile organs became progressively shortened and increased in number.

There is another hypothesis which has been maintained by Entz and Maupas amongst others, in which the Ciliata are derived from the Rhizopoda through such forms as Actinobolus and the Enchelinidæ in general, two types of which have been found in Van Cortlandt water, Lacrymaria and Actinobolus. Before speaking of this hypothesis in detail I will add a few notes on these two genera.

Lacrymaria olar Ehr.

Of all known micro-organisms, *Lacrymaria olar* is the most remarkable for its elasticity, and manner in which it stretches out a neck-like portion bearing the mouth. The wonderful variability of this portion of the body cannot be represented in a figure, but when one has witnessed the contortions which it undergoes he will never forget the organism. Sometimes the "neck" is stretched forwards in a straight line to a distance equal to six times the diameter of the body; again it may be wound around the body of the animal from the insertion point to the posterior end of the animal, and forward again on the other side; and even then it may stretch out to a considerable distance in advance of the forward end; or, on the other hand, it may be retracted until the mouth appears to be merely the extremity of an ovoid body.

Lacrymaria is not an uncommon form, and in the present connection it is mentioned chiefly for its bearing upon the hypothesis as to the origin of the Suctoria.

Actinobolus radians St.

This infusorian is much more rare than Lacrymaria, and from its rarity perhaps more interesting. It was first described by Stein, then by Entz, who studied it very carefully, and later by Von Erlanger, who made out a number of minor points of structure. It is almost always found in the company of certain forms of Suctoria, Von Erlanger alone not finding these associates. In the Van Cortlandt water the organism was overlooked for some time, because of its supposed identity with the suctorian Sphærophrya, which was present in considerable numbers. Actinobolus is a small spherical organism not much larger than a Urocentrum, and when at rest resembles a Sphærophrya, which in turn resembles an Actinophrys. It is only when this form is studied with a medium high power that a fringe of vibrating cilia can be made out around the profile of the periphery. It may then be seen that there are groups of long cilia (ten or twelve to a group) arranged about the base of each of the long tentacle-like processes, which give to the organism, when at rest, the aspect of a heliozoön (Fig. 3). The tentacles are the most interesting feature of the ciliate, and their function has been in considerable doubt. Stein was unable to assign any function, but described them as retractile, like the tentacles of the Suctoria, to which he compared them, observing at the same time that they might be entirely withdrawn into the body, leaving no trace of their former presence. Entz thought that they might assist the organism in getting

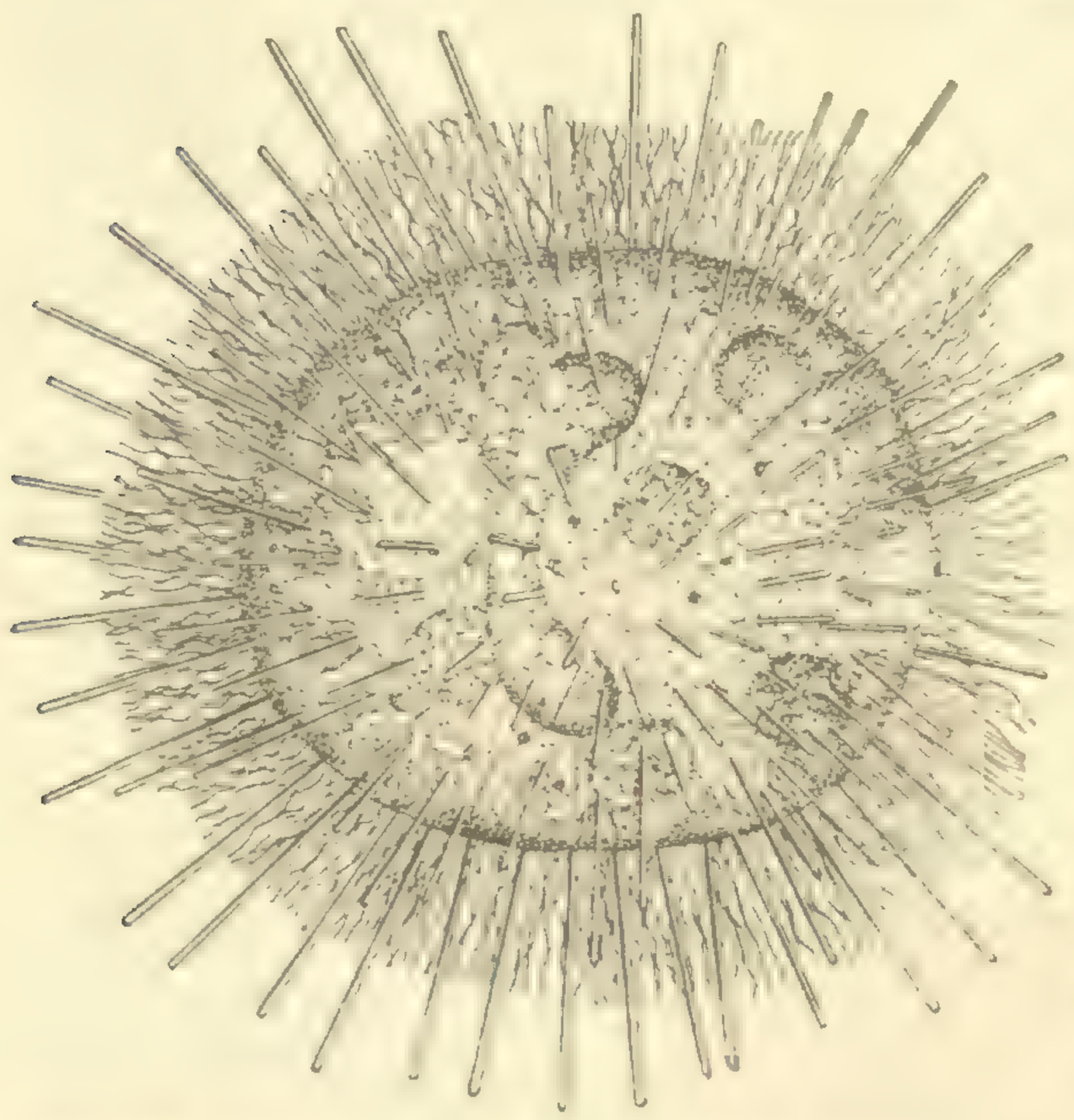


FIG. 3. — *Actinobolus radians* St. The tentacles are partially drawn in and the animal is represented from the side with the small mouth in advance. The nucleus is elongate and constricted. Six Halteria are faintly represented in the endoplasm. × 1200.

food, and observed that the ends of the tentacles were attached to threads of algæ which appeared to be ruptured at the points touched, and he concluded that a secretion of some sort is poured out upon the alga by the tentacle. He also maintained that the organism is exclusively a plant-eater. Von Erlanger described the tentacles as possessing a stiff dart or needle-like trichocyst at the end ; these, he said, are drawn in with the tentacle until, when the tentacles are entirely withdrawn, they form a peripheral layer of trichocysts as in a Prorodon. He also observed that the organism may swallow other living forms and described the seizure of a small flagellate by the cilia about the mouth opening.

There are a few points which I may be able to make in addition to the above. The organism, when feeding, lies attached to the bottom of the vessel by its oral tentacles (*i.e.*, those about the mouth, which are no different from the others on the animal), and mouth downwards. This brings the posterior end of the organism upward, and the anal spot and contractile vacuole can be easily seen and studied while the animal is in this position. The vacuole is not in the center of the dorsal surface, but lies a little to one side (Fig. 4). The tentacles are almost as distensible as the neck of Lacrymaria, and may stretch out a distance of two and a half diameters of the organism, or retract until they disappear in the body. They arise from the substance of the cortical plasm, which is covered by a very thin cuticle or outer membrane, but they cannot be traced into the inner plasm. The cilia are more like flagella than cilia, and move with a vibratory rather than a stroking motion ; while resting they are easy to follow, but when the tentacles are all withdrawn the motion becomes much more rapid, and only the general waving surface can be made out.

It is when the animal is quiet that it takes in food. It remains for hours, sometimes, without giving a sign of feeding, but the tentacles are stretched out to their greatest length and it appears to be merely waiting for something to come. Things do come, especially flagellates like Chilomonas, Trachelomonas, Euglena, etc., and ciliates such as Urocentrum, Paramœcium, Bursaria, Colpoda, etc., but no attention is

paid to them. Finally, however, a particular kind of ciliate comes along, *Halteria grandinella*, which, sailing along with its graceful but spasmodic motion, suddenly finds itself on the end of one of the long tentacles of Actinobolus. The captive whirls

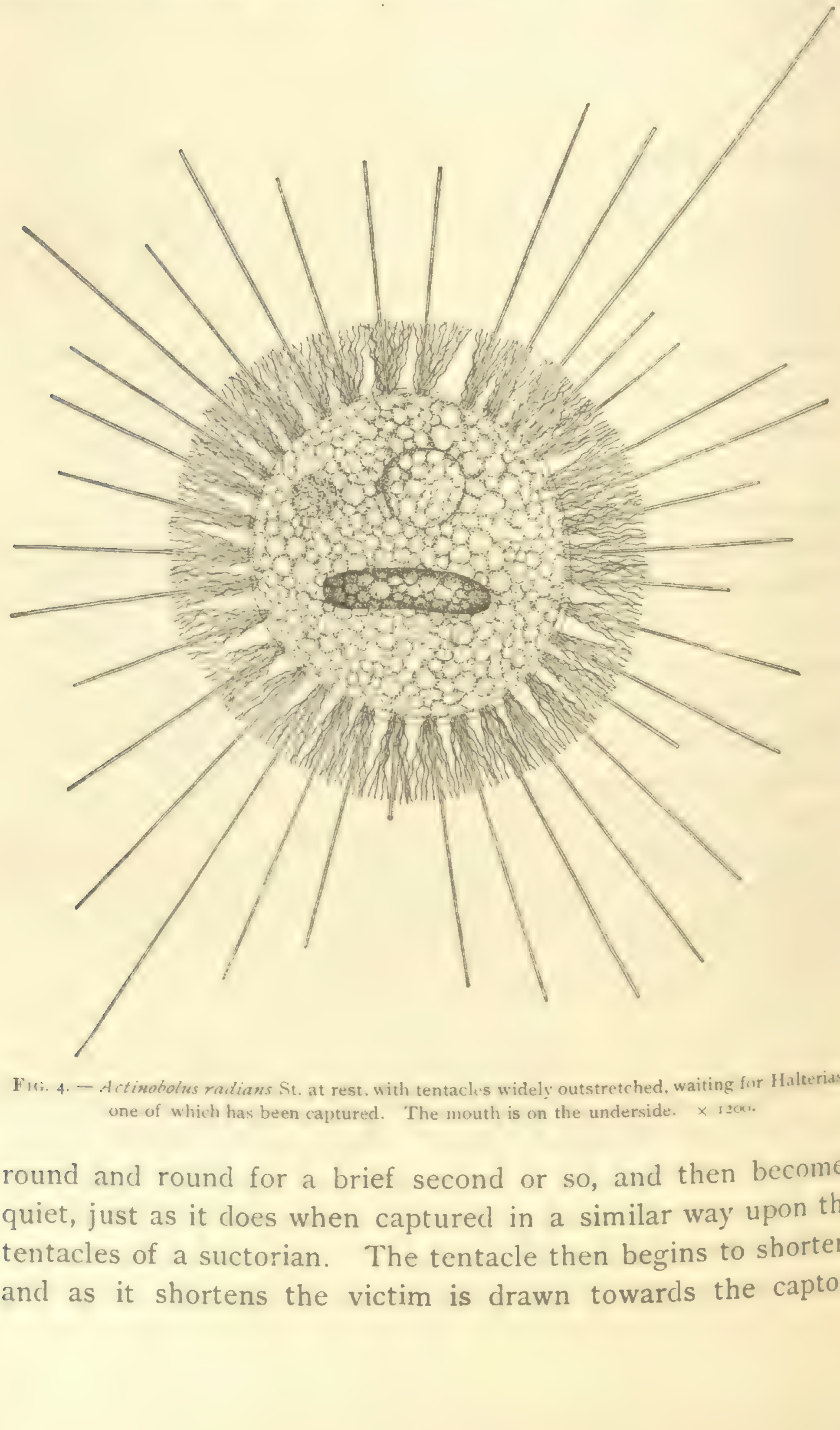


FIG. 4. — *Actinobolus radians* St. at rest, with tentacles widely outstretched, waiting for Halterias, one of which has been captured. The mouth is on the underside. × 1200.

round and round for a brief second or so, and then becomes quiet, just as it does when captured in a similar way upon the tentacles of a suctorian. The tentacle then begins to shorten, and as it shortens the victim is drawn towards the captor,

perhaps to the side, perhaps on top ; wherever the prey may be drawn, however, it is gradually worked downwards by the tentacles to the underside toward the mouth, and then with a single swallow it is transferred to the waiting endoplasm in which it is digested. So insatiable is the appetite of this form that, after adding water containing Halteria in abundance, I have seen it swallow in the manner described above no less than ten individuals within half an hour, after which its endoplasm appeared filled with foreign bodies, as Von Erlanger described in the form he observed.

This then is the function of the tentacle, a food-catching organ or set of organs ; the trichocyst which Von Erlanger described, or its analogue (I was unable to make it out as described by Erlanger), brings down the prey, and the tentacle, by shortening, fetches it to the mouth. The tentacle itself is inserted in the Halteria, for it can be seen with the greatest distinctness when the victim becomes quiet, and I believe that the dart at the end as described is not discharged into the prey but is driven into the soft body of the victim as a minute spear, with shaft attached.

When fully fed or when warmed by artificial means the animal detaches itself and draws in its tentacles. It then swims mouth first in a rambling sort of way, turning the while on its longer axis (Fig. 3).

Apart from the general biological interest which such an organism has, there is a considerable interest from a theoretical point of view. Maupas maintained in 1881 that the Ciliata have been derived from the Rhizopoda through the Suctoria, and that the tentacles are to be compared with pseudopodia, while the forms with both cilia and tentacles were considered intermediate. So important was the group of tentacle-bearing forms considered that Mereschowsky formed a special group — the Suctociliata — for their reception. Neither Maupas, Entz, nor Mereschowsky could regard the tentacles in these forms as food-taking organs similar to those of the Suctoria, and could assign them no function other than that of assisting in the capture of aliments. As well known, the tentacles in the Suctoria are for the most part hollow, and the food is taken in some manner

through the open ends. Maupas regarded them, together with the tentacles of Actinobolus, Ileonema, and Mesodinium, as pseudopodia, and thought that through them the ciliates came from the Suctoria and the latter from the Rhizopoda. This theory of the origin of the Ciliata from Rhizopoda has but an historical interest, and it is now very generally if not almost universally held that the Suctoria came from the Ciliata ; while the tentacled forms of ciliates are merely independent modifications for special ends and with no phylogenetic significance. A number of minor points suggest the close relation of the forms like Actinobolus to the Suctoria, but more careful consideration leaves little reason to doubt the view that they represent merely parallel evolution, being adaptive features for special ends.

THE MOLLUSCAN FAUNA OF THE GENESEE RIVER.

FRANK COLLINS BAKER.

THE study of faunal distribution has always been a favorite occupation of zoölogists, and particularly of those interested in the study of the Mollusca, as in this branch we find a very large number of species, covering wide areas and subject to every variation of environment. In no department of the Mollusca is this of such absorbing interest as in the fresh-water forms (unless we except, perhaps, the air-breathing pulmonates), especially those inhabiting a large river where there are several barriers to the homogeneous distribution of its shell fauna. During the past summer the writer spent several months in such a study of the Genesee River, where the environments are quite different in several parts of the stream, with a corresponding difference in the mollusk fauna. The river was carefully surveyed from near its mouth on Lake Ontario to beyond South Park, a distance of ten miles. A large collection was made, which is now in the museum of the Chicago Academy of Sciences. My thanks are due to Miss Edna E. Hall for valuable assistance in collecting, and to Rev. John Walton for many notes.

The Genesee River rises in Potter County, Pennsylvania, and flows in a generally northward direction for about 120 miles, emptying into Lake Ontario, seven miles north of Rochester, N. Y. The Genesee valley is very fertile, and the river flows between low banks rich in vegetation. Before passing Rochester the river is deep, the banks muddy, and the current steady but not very swift. From a point a little north of Genesee Valley Park (or South Park) the bottom of the river becomes very rocky, the current swift, and at Rochester the river drops to the valley below in three series of falls of considerable magnitude.

The geography of the river from South Park to the lake may be thus described: From south of Genesee Park to within a short distance of a small dam it is broad, deep on one side and affording a shelving, shallow bank on the other, the bottom being composed of a clayey mud. Unios, Campelomæ, Goniobases, Sphæria, and Physæ are here very common. Just before reaching the dam the river shallows very perceptibly, flowing rapidly over great ledges of limestone. *Lampsilis luteolus* and *L. iris* are very common here, and also Goniobasis, while Physa is not quite so common.

Below the dam, which is now broken and very much out of repair, the river flows rapidly over a rocky bed, in many places the water being so shallow that persons can wade across. The right bank is very rocky, more so than the left, and forms little sheltered bays here and there, in which Goniobasis and Physa live by thousands, the former making a veritable pavement in some places. *Lampsilis luteolus* is also common, although apparently preferring the middle of the river. Along the bank here the Unios lie in great windrows, their dead shells piled up like the débris on an ocean shore. In this pile of shells such species as *Lampsilis iris*, *L. luteolus*, *Quadrula rubiginosa*, *Lampsilis complanatus*, and *Alasmodonta rugosa* are common. The water near the rocky shore also affords good retreats for the mollusks.

Near the Erie Railroad bridge the water deepens, and the Unios begin to thin out, although *Lampsilis luteolus* seems to be as common as ever. Goniobasis also flourishes, while Physa almost dies out. Near Clarissa Street bridge the water becomes still deeper, and the only species found are *Lampsilis luteolus*, *L. iris*, *L. complanatus*, and Goniobasis, with a stray Campeloma or Sphærium. Physa seems to have disappeared completely. Below Clarissa Street bridge the water deepens to the state dam, beyond which it is very shallow and rocky, so far as known affording no mollusks save an occasional Goniobasis or Campeloma. At the dam the water is deflected in a large stream for factory uses and again reaches the river at the first falls.

At Rochester, below the bridge of the New York Central Railroad, the river drops to the valley below in a fall 96 feet in height, cutting through Niagara limestone and Clinton shale. Below this fall the current is rapid, the river flowing in a sinuous course, leaving on either side at intervals a low, flat piece of ground with a shallow, shelving shore, the opposite side, however, being very deep. The upper part of the river is so contaminated with oil and gas products from the gas works and a number of manufactories that mollusks cannot live here. A short distance down the river, where the water is not so badly contaminated, a few Physæ, Planorbis, and Limnæa live. These grow more abundant as the purer waters are reached. About two miles farther north a second fall occurs, 26 feet in height, cutting through the Clinton shale. Below this fall the river runs swiftly, is very deep, and forms a circular pool just beneath the fall. The walls are very steep and stony, the river having cut away the soft shale, leaving great projecting ledges. Physa, Planorbis, and Limnæa are here notably abundant, living on ledges of rock where the water is a few inches deep.

A few hundred feet north of this fall a third one occurs, cutting through Medina sandstone 83 feet in height, and the river drops to the valley below, flowing at first rather rapidly, but after a mile or so rather quietly, between well-wooded banks 210 feet in height. The river is here bordered by many swampy flats covered with rank vegetation, and the shores are muddy. Near the falls the river is somewhat shallow, flowing over fallen rocks, but it soon becomes quite deep. The genera present are Limnæa, Physa, Planorbis, Bythinia, and Calyculina; Limnæa and Planorbis predominating. In the mouth of the Genesee there are some eight or ten species of Unios, with some gastropods, which have come in from Lake Ontario, but they have not as yet reached far enough up the river to form a factor in this discussion.

The following table shows the comparative distribution of the species in each section of the river. An asterisk (*) indicates that the species is very abundant, while the dagger (†) shows that the species is more rarely found.

TABLE OF COMPARATIVE DISTRIBUTION.

ABOVE FIRST FALLS.	BETWEEN FIRST AND SECOND FALLS.	BETWEEN SECOND AND THIRD FALLS.	LOWER RIVER.
Planorbis trivolvis *	Planorbis trivolvis *	Planorbis trivolvis *	Planorbis trivolvis *
Limnæa palustris †		Limnæa palustris †	
	Limnæa catascopium *	Limnæa catascopium *	Limnæa catascopium *
	Limnæa caperata †	Limnæ caperata †	Limnæa caperata †
Ancylus rivularis †			
Physa integra *		Physa integra †	
	Physa sayii *	Physa sayii *	Physa sayii *
			Physa gyrina *
			Physa heterostropha †
Goniobasis livescens *			Bythinia tentaculata
Campeloma rufum *			
Campeloma decisum *			
Campeloma integrum †			
Calyculina transversa †			Calyculina transversa *
		Calyculina partumeia	Calyculina partumeia †
Sphærium simile *			
Sphærium stamineum *			
Anodonta lewisii †			
Alasmodonta pressa *			
Alasmodonta rugosa *			
Alasmodonta deltoidea †			
Alasmodonta marginata †			
Strophitus edentulus *			
Anodontopsis ferussacianus †			
Quadrula rubiginosa *			
Quadrula undulata †			
Lampsilis iris *			
Lampsilis luteolus *			
Lampsilis ventricosus †			
Lampsilis alatus †			
Lampsilis radiatus †			
Lampsilis complanatus *			
Lampsilis tappianus †			

A study of the table will show a few interesting facts. The first will be the abundance of Unios above the falls and their total absence below, showing that the upper falls afford an insurmountable barrier to their further distribution in this direction. Another fact of equal note is the abundance of certain gastropods in all four sections of the river (Planorbis, Physa). The general absence of ctenobranchiates below the falls (Bythinia excepted) is noteworthy. Bythinia is a recent addition to the fauna of the lower river, appearing in immense numbers in 1898. It was very common at the mouth of the river, in Lake Ontario, in 1895, and in these three years it became one of the most abundant mollusks in the lower river.

The distribution of Physa is also peculiar. *Physa integra* is the dominant and (so far as I know) the only form above the falls, and *Physa gyrina* below. *Physa sayii* is the only species between falls 1 and 2 and is very abundant only between the upper and lower falls, a very peculiar distribution, for which I cannot account. *P. integra* does not occur between the upper river and falls 2 and 3, and I was not able to find it between falls 1 and 2, which, if borne out by future observations, offers an interesting phase of distribution. Why *P. integra* should be so interrupted in its distribution may be accounted for by two hypotheses: (1) that specimens may have been carried over the first and second falls and found lodgment above the lower falls; or (2) specimens might have been carried by birds or other animals. Why *Physa sayii* is found everywhere except in the upper river is also an interesting question.

Limnæa seems to be evenly distributed, and yet in this genus we find the same peculiar distribution as in Physa. *L. palustris* has been collected in small numbers in the upper river, but *L. catascopium* and *L. caperata* take its place in the other three regions, the former being very abundant. Ancylus has been found only in the upper river, in the dead valves of Unios, but it may be that it inhabits all parts of the river. As in the case of *Physa integra*, we find the distribution of *Limnæa palustris* to be peculiar, jumping, as it does, the first fall and occurring sparingly between falls 2 and 3. *Planorbis trivolvis* is the only evenly distributed species. Among the bivalves,

Calyculina transversa is interrupted in its distribution, but, like *Physa gyrina*, *P. heterostropha*, and *Bythinia tentaculata*, may have come up the river from Lake Ontario. This, however, will hardly account for *Calyculina partumeia*, which is found in the lower river and between falls 2 and 3.

As one glances over the table the fact presents itself that there is a marked division in the faunas between the upper river and the series of falls, and the lower river. This may be accounted for by the fact that for a distance of about two miles above the first fall the river is shallow and very rocky, in fact flowing over great ledges of Niagara limestone, and the Unios all seem to prefer the deeper, more quiet waters above this section of the river, only a few stragglers, like *Lampsilis luteolus*, *L. iris*, and *Alasmodonta rugosa*, being found in this rocky region. The writer was unable to find Unios within a half mile of the upper falls, showing conclusively that this environment is unsuitable for them. Another reason why Unios are not found below the falls is probably that their heavy shells and also their habit of burying themselves in the mud prevent them from rising to the surface and being swept over the falls, as might be the case with Planorbis, Limnæa, or Physa, which come periodically to the surface for air.

The foregoing discussion indicates that a series of falls like those at Rochester will prove an effective barrier to the distribution of some mollusks (as the pelecypods with mud-burrowing habits and the ctenobranchs, which cling to the rocks and do not come to the surface), while to others (like the fresh-water pulmonates, which come to the surface frequently and hence could be swept over the falls) it is not a barrier. Future studies and collections, however, may modify the above conclusions.

THE CONCHOMETER.

HAROLD S. CONANT.

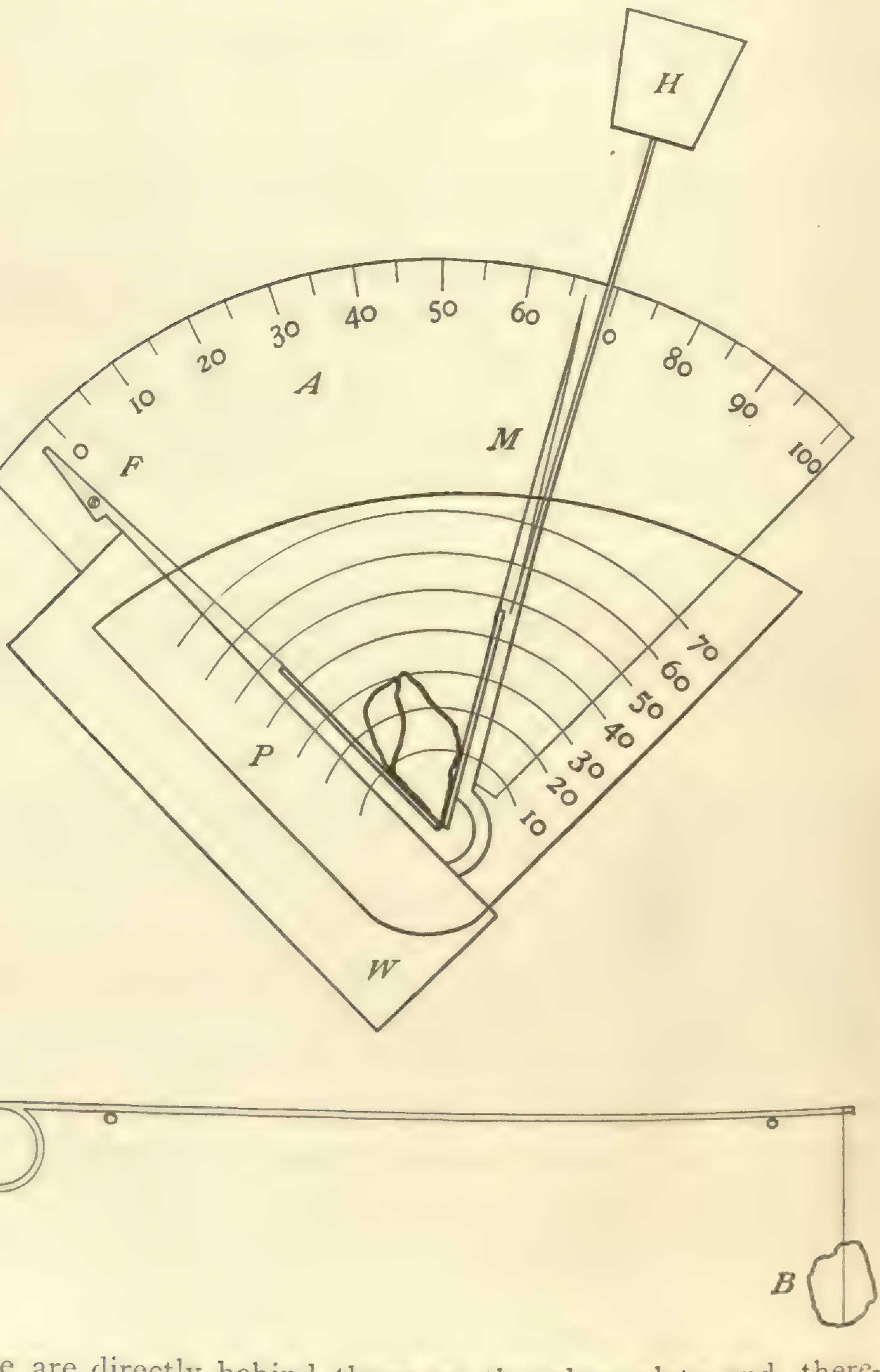
In connection with a recent study of variation in *Purpura lapillus*, it seemed necessary to measure the apical angle of the shell, among other features, and since no apparatus adapted to this purpose was known, an instrument, which I have called a *conchometer*, was constructed.

About 4000 measurements have been taken by this means; and so well did they correspond with theoretical considerations that the writer believes the value of the instrument to have been proven. With the possibility that those who are using the statistical method for studying variation may find it suited to their purpose, a description is here given.

It consists of two parts: (1) a device for measuring angles at the ends of the shell, and (2) a device for measuring the long axis of the shell and the distance from the apex of the shell to the aperture. The first consists of an ordinary drawing compass, of which one arm, *F*, is firmly attached to a board, and the other, *M*, may be moved over a graduated arc, *A*, which is also attached to the board. The arc reads to half-degrees and has its zero-point at the fixed arm. Attached to each arm of the compass is a plate of metal some 2 inches long and $\frac{3}{4}$ of an inch wide, standing vertically to the board, so that only the edge is visible in the figure. The two plates are so placed on the arms that they just touch each other at the pivot of the compass. When the board is set in position, vertically, the plates form a V whose angle may be made larger or smaller by the adjustment of the movable arm by means of a suitable handle, *H*. It is with this part of the apparatus that the apical angle of the shell may be measured, as described later.

The second part of the apparatus, by means of which linear measurements are taken, consists of two scales graduated to millimeters by means of concentric lines. One is etched upon

a glass plate, *P*, placed in front of the V, parallel to the board, and secured to it by means of a block, *W*; and the other is a ruled scale attached to the board. The lines on the second



scale are directly behind those on the glass plate and, therefore, are not seen in the figure. The two scales are exactly alike, except that one is etched on glass and the other ruled on

paper. The object of having two scales is to avoid parallax errors in reading. The paper scale is protected from dampness (and consequent warping) by a sheet of transparent celluloid.

A few words may be necessary to explain the working of the instrument. A shell of *Purpura lapillus* is lowered into the V, and the arms are adjusted to fit the apex. It is not a difficult matter to do this, and the adjustment may be made more accurately by having the plates polished to mirror-like brightness and using then the well-known method of determining contact by reflection. The shell having been well fitted, the position of the point of the movable arm may be read on the before-mentioned arc, *A*, and the apical angle be thereby determined. A simple bob, *B*, is used to lower the shell into the V and to withdraw it. This is made of stiff copper wire, with a small ball of cotton wool dangling at the end of a piece of finer wire. The cotton wool is thrust into the aperture of the shell, and in this way the latter is held firmly, apex downwards.

The total length of the shell and the distance from the apex to the aperture are both measured while the shell is in the position just described and shown in the figure. It is important to note that the zero-point of the linear scale lies at the apex of the V, and that the apex of the introduced shell must necessarily be at that point. Hence the total length of the shell will be determined by observation of the part of the shell lying farthest from the zero of the scale, and when found it may be read directly by means of the concentric lines. In the same way the distance from the apex to the aperture may be read directly by noting where the aperture comes on the scale. Care should, of course, be taken always to present the ventral side for measurement. After some practice the measurements may be taken rapidly and accurately.

Dow Academy, Franconia, N. H.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XVI. The Phalangida.

NATHAN BANKS.

The Phalangida, or the Opiliones as they have been called by some authors, form a very distinct order of the Arachnida. The cephalothorax is of one piece, but often presenting one or two incomplete transverse furrows. There is also a furrow on each side, which is supposed to indicate that the portion beyond is a part of the pleura. On this part on each anterior side there is a small, somewhat circular depression, with a membranous bottom; these are called the lateral pores. On the middle line of the cephalothorax, and frequently near the anterior margin, is a rounded elevation, with a simple eye on each lateral face; this is the eye-tubercle, or eminence. The abdomen is united to the cephalothorax by the whole of its breadth, so that there is no trace of a pedicel. It is always quite broad when compared to its length, never slender, and usually quite high; in the males it is often tapering behind. There are considered to be eight segments in the abdomen, but in many forms the basal and median ones are poorly defined on the dorsum; on the venter there are usually six distinct segments. The underside of the cephalothorax is occupied by the coxæ and a median piece similar to and often called a sternum. It is, however, something quite different; it is the basal ventral segments advanced forward over the bases of the coxæ; it carries with it the opening of the genital organs, which thus, in certain forms, appears to issue close to the mouth. This advancement of the abdomen is so pronounced in many of our common forms that the coxæ are crowded at base and so appear to radiate from a central point. The legs are usually very long and slender, though tarsi and

ofttimes several of the other joints are divided into smaller portions by what are termed false articulations. Each tarsus is terminated by one or two claws.

The habits of the Phalangida are rather simple. With our common forms the length of life is but one year. The eggs are laid in the ground, or in crevices of wet or decaying wood, during the summer or fall; the young hatch in late fall or early spring. At birth they have the general appearance of

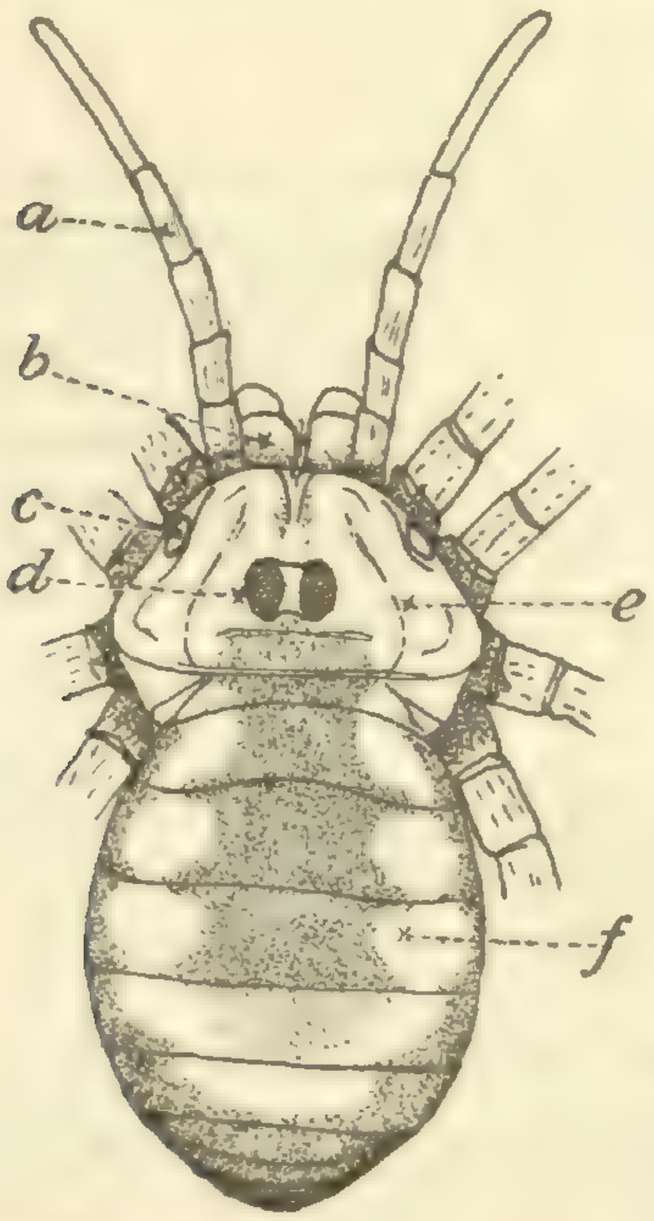


FIG. 1.

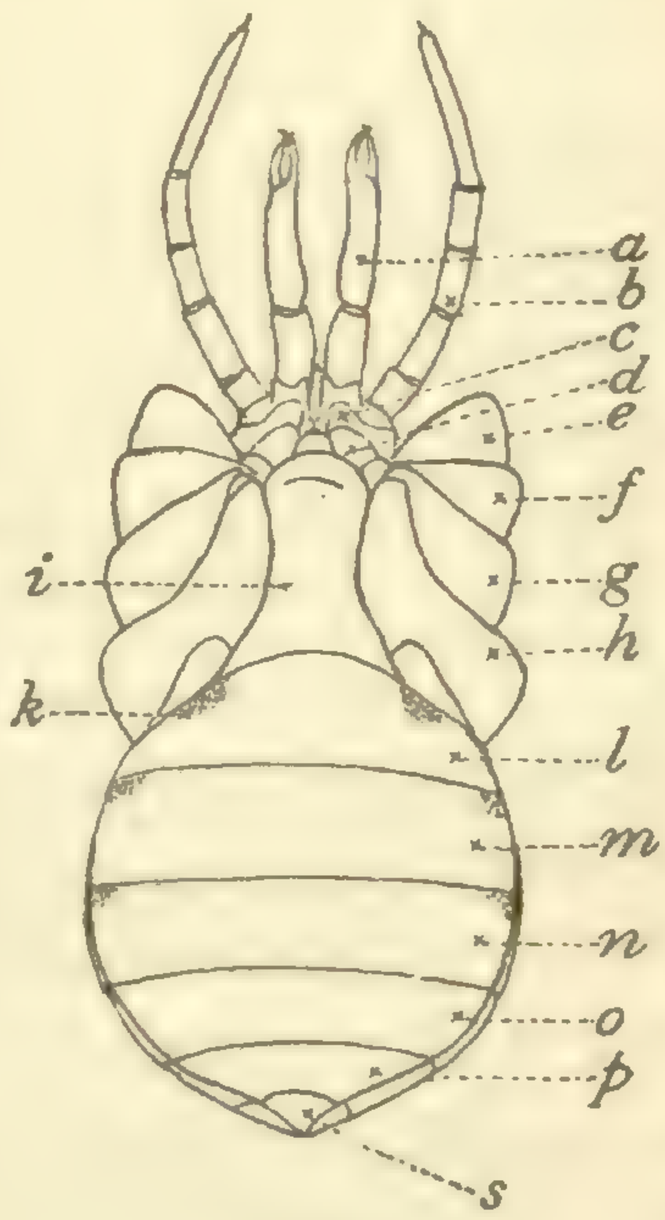


FIG. 2.

FIG. 1. — Dorsal view of a phalangid. *a*, palpus; *b*, mandible; *c*, lateral pore; *d*, eye-tubercle; *e*, cephalothorax; *f*, abdomen.

FIG. 2. — Ventral view of a phalangid. *a*, mandible; *b*, palpus; *c*, maxilla; *d*, pedal lobe; *e*, coxa I; *f*, coxa II; *g*, coxa III; *h*, coxa IV; *i*, advancement of abdomen; *k*, spiracle; *l*, 2d ventral segment; *m*, 3d ventral seg.; *n*, 4th ventral seg.: *o*, 5th ventral seg.; *p*, 6th ventral seg.; *s*, anal plate.

the adult, often, however, with slight modifications. Some species having short palpi when adult have long palpi when young. In several of our species the young have the patella of the palpus with a long branch, whereas it is absent or nearly so in the adults.

They spin no web and make no retreat of any kind. They usually move slowly, but a few can run rapidly. Some species occasionally congregate in numbers on trees. They feed mostly on living insects, but sometimes on decaying animal matter. They appear to have few enemies, but their long legs or hard

bodies are a serviceable protection. When handled they often exude a whitish fluid, which in some species has a disagreeable odor.

The points for the separation of species are often best observed in the males; this is especially true in the large genus Liobunum, in which the females are not known for several species. The males, as a rule, have more slender legs and palpi, and a more tapering abdomen; but in some species the abdomen of the male is very short and broadly truncate. In Liobunum the last joint of the male palpus shows a row of small denticles beneath. In a few forms the male has the hind coxæ enlarged. In several cases there are colorational differences between the sexes. In many forms the male is more spinose than the female. The order Phalangida is usually divided into two suborders: Mecostethi (Laniatores of Koch) and Plagiostethi (Palpatores of Koch):

First ventral segment of abdomen not reaching in front of hind coxæ; hind tarsi with two claws at tip or else with a compound claw; palpus with tibia and tarsus more or less depressed; hind legs usually the longest . . . . . MECOSTETHI

First ventral segment of abdomen extends much in front of hind coxæ; all tarsi with but one simple claw; palpus with tibia and tarsus cylindrical, second legs the longest . . . . . PLAGIOSTETHI

MECOSTETHI.

This suborder is represented in our fauna by two families:

1. Hind pair of coxæ free at apex; spiracles obscure . PHALANGODIDÆ
   Hind coxæ wholly united to the venter; spiracles distinct COSMETIDÆ

The Cosmetidæ have but one genus, Cynorta, of three species, in the United States; they can be distinguished as follows:

1. Two acute spines near end of dorsal shield . . *C. ornata* Say (Fla.)
   Two rounded tubercles instead of spines . *C. sayii* Sim.[1] (S. States)
   Neither spines nor tubercles; body with two pale spots above
   C. bimaculata Banks (Calif.)

Our Phalangodidæ are arranged in four genera:

1. One compound claw to each of the four posterior tarsi; palpi not as long as the body; eyes present . . . . . Sclerobunus
   Two simple claws to each posterior tarsus 2

[1] Includes *C. albolineatus* Sœrensen.

2. Eye-tubercle arising from anterior margin of the cephalothorax; palpi shorter than the body . . . . . Sitalces
Eye-tubercle arising back from the margin; palpi longer than body. 3

3. Tarsus II about twice as long as body, its joints very slender; no eyes Phalangodes
Tarsus II about length of body; eyes often present . . Scotolemon

SCOTOLEMON Lucas:

1. Eye-tubercle ends in a spine; second joint of palpus three times as long as wide; body with short, stout spines . *S. spinifera* Pack. (Fla.)
Eye-tubercle without spine; second joint of palpus about twice as long as broad 2

2. Tarsus II with short joints; palpi stouter
S. flavescens Pack. (Ky., Ind., Va.)
Tarsus II with joints slender; palpi more slender
S. californica Bks. (Calif.)

SCLEROBUNUS Banks:

Color red, tips of legs black . . . . *S. robustus* Pack. (W. States)
Color brown, tips of legs yellowish *S. brunneus* Bks. (Wash., Alaska)

SITALCES Simon . . . . . *S. californica* Bks. (Calif.)

PHALANGODES Tellkampf. . . . *P. armata* Tellk. (Mammoth Cave)

PLAGIOSTETHI.

Three families occur in the United States:

1. Last joint of palpus with a claw at end, this joint longer than preceding one (except in male of Protolophus) . . . PHALANGIDÆ
Last joint of palpus much shorter than penultimate, no claw at its tip. 2

2. Palpi very short, concealed under the projection of eye-tubercle TROGULIDÆ
Palpi long and prominent. . . . . NEMASTOMATIDÆ

Our genera of Phalangidæ are separated as below:

1. Male with palpus enlarged, last joint shorter than penultimate; female with patella of palpus provided with a long branch; palpal claw smooth; a row of teeth on sides of coxæ. (Protolophini) Protolophus
Last joint of palpus longer than penultimate; patella without branch in adult 2

2. Eye-tubercle of enormous size, three long spines on femur of palpus (Caddini) Caddo
Eye-tubercle of normal size 3

3. A group of spinules on anterior margin of the cephalothorax and the eye-tubercle spinose; palpal claw smooth, rarely if ever with lateral rows of teeth on coxæ, frequently with spines on femur of palpus (Phalangini) 10

Eye-tubercle smooth, if spinose then no group of spinules on anterior margin of the cephalothorax 4

4. Palpal claw denticulate, a row of teeth (adult) on sides of coxæ, distinct at least on anterior side of coxa I, legs usually long . (Liobunini) 5

Palpal claw smooth, no such rows of teeth on coxæ, legs usually shorter . . . . . (Leptobunini) 7

5. Body very hard and granulate above and below; legs very short, fourth pair nearly as long as second pair . . . . . Mesosoma

Body softer, although often subcoriaceous; rarely granulate below; legs longer, fourth pair much shorter than second pair 6

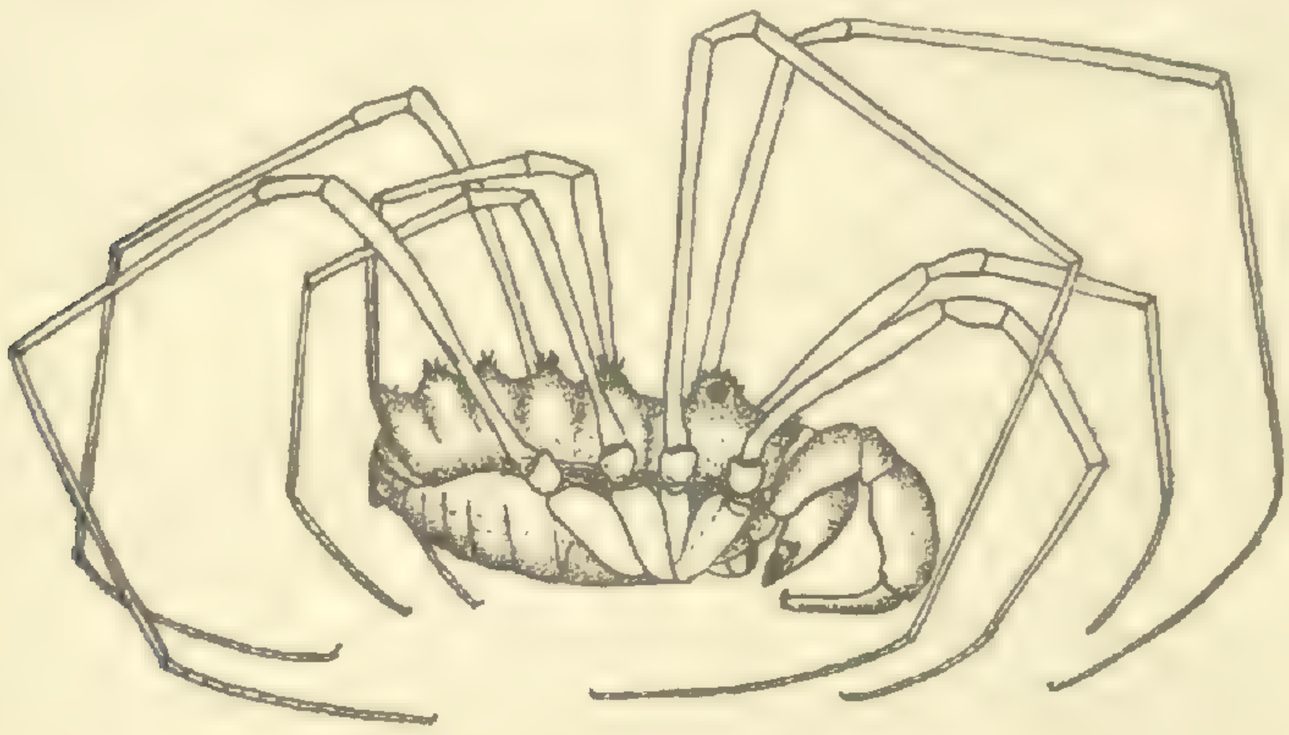


FIG. 3.—*Protolophus singularis.*

6. Femur I longer than body or in some females a little shorter, but longer than width of body . . . . . Liobunum

Femur I shorter than body, in females not as long as width of body Hadrobunus

7. Inner margin of patella extended; body very hard and rough; eye-tubercle spinose: coxæ III and IV in males enlarged . Trachyrhinus

Inner margin of patella not extended, or at least the body quite soft 8

8. Legs slender and long as in Liobunum, coxa II not shut out by I and III . . . . . Leuronychus

Legs much shorter, femora I thickened or not as long as width of body; eye-tubercle smooth 9

9. Femora and tibiæ I and III thickened; coxa II shorter than I Eurybunus

Femora and tibiæ I and III not thickened; coxa II about as large as I . . . . . Leptobunus

10. Femur of palpus provided with prominent spines 11

No such prominent spines 12

11. No false articulations in metatarsus I; eye-tubercle more remote from anterior margin . . . . . Lacinius

At least one false articulation in metatarsus I; eye-tubercle nearer to margin . . . . . Oligolophus

12. Femora and tibiæ I and III thickened; coxa II completely shut out by I and III . . . . . Globipes
Femora and tibiæ I and III normal; coxa II not shut out by I and III 13
13. Two prominent supra-mandibular teeth; dorsum punctate Homolophus
No such teeth 14
14. Femur I longer than width of body . . . . . Phalangium
Femur I shorter than width of body . . . . . Mitopus

PROTOLOPHUS Banks:

Abdominal tubercles unarmed . *P. tuberculatus* Bks. (Calif., Tex.)
Abdominal tubercles with a few spinules, male palpi larger. *P. singularis* Bks. (Calif.)

CADDO Banks . . . . . *C. agilis* Bks. (N. Y., D. C.)

PHALANGIUM Linné:

Palpi very long, in male longer than body, in female longer than width of body; the second joint of male mandible is prolonged above in a spur . . . . . *P. longipalpis* Weed (Ark.)
Palpi much shorter, in female scarcely as long as width of body; no spur on mandibles of male . . . *P. cinereum* Wood (N. States)

MITOPUS Thorell:

1. Tibia II is much longer than metatarsus II; one false articulation in metatarsus I; eye-tubercle about its diameter from anterior margin *M. californicus* Bks. (Calif.)
Tibia II is subequal to or shorter than metatarsus II 2
2. Gray and white, no false articulation in metatarsus I *M. dorsalis* Bks. (Alaska)
Brown or black and white, two false articulations in metatarsus I *M. montanus* Bks. (N. H.)

LACINIUS Thorell:

Metatarsi I and III banded in middle; spines at tips of femora and patellæ very prominent . . . . . *L. texanus* Bks. (Tex.)
Metatarsi I and III unbanded; legs longer, spines at tips of femora and patellæ less prominent . . . *L. ohioensis* Weed (E. States)

OLIGOLOPHUS Koch . . . . . *O. pictus* Wood (N. E. States)

HOMOLOPHUS Banks . . . . . *H. biceps* Thor.[1] (Colo. to Wash.)

GLOBIPES Banks . . . . . *G. spinulatus* Bks. (Calif.)

LEPTOBUNUS Banks:

Apices of coxæ dark, tibia I with one dark band, palpus lineate with brown . . . . . *L. borealis* Bks. (Alaska)
Apices of coxæ pale, tibia I with two dark bands, palpus not lineate *L. californicus* Bks. (Calif.)

[1] Includes *H. punctatus* Bks.

EURYBUNUS Banks :

Body smooth ; leg IV nearly as long as II . *E. brunneus* Bks. (Calif.)

Body with transverse rows of spinules ; leg IV much shorter than II *E. spinosus* Bks. (Calif.)

TRACHYRHINUS Weed :

Coxæ pale, maculate with brown, legs mostly pale *T. marmoratus* Bks. (N. Mex.)

Coxæ unicolorous, legs mostly black . . . *T. favosus* Wood (Colo.)

LEURONYCHUS Banks :

Body with a brown dorsal vitta, patellæ of legs brown lineate with white . . . . . *L. pacificus* Bks. (Calif., Wash.)

Body without vitta, patellæ not lineate . . *L. parvulus* Bks. (Wash.)

FIG. 4. — *Lacinius texanus*.

LIOBUNUM Koch. *Males :*

1. A distinct spur on the femur of palpus, dorsum yellowish, without stripe, trochanters concolorous with coxæ *L. calcar* Wood (N. States)

   No such spur 2

2. Palpus, except tarsus, mostly black 3

   Palpus yellowish or brownish 4

3. Dorsum dark, often with two large pale spots behind, trochanters usually pale . . . . . *L. exilipes* Wood (W. Coast)

   Dorsum pale yellowish, no stripe, trochanters and bases of legs black . . . . . *L. nigripalpi* Wood (E. States)

4. Femur, patella and tibia of palpus plainly incrassate, dorsum with a black stripe, trochanters dark brown . *L. crassipalpis* Bks. (D. C.)

   Palpal joints not incrassate 5

5. Femur of palpus very long, curved, extending much above surface of cephalothorax, dorsum with a distinct black stripe, trochanters black . . . . . *L. vittatum* Say [1] (U. S.)

[1] Includes *Liobunum dorsatum* Say.

Femur of palpus shorter, dorsum without distinct black stripe . . . 6

6. Dorsum dark, with two large yellowish spots on union of cephalothorax and abdomen . . . . . *L. bimaculatum* Bks. (Calif.)

Not so marked 7

7. Apex of tibia II white, trochanters black, body short *L. longipes* Weed (E. States)

Apex of tibia II not white 8

8. Apex of femur I white, preceded by a black band, coxæ pale outside . . . . . *L. townsendi* Weed (N. Mex., Tex.)

Femur I not so marked 9

9. Trochanters dark, contrasted in color with the coxæ 10

Trochanters pale, concolorous with coxæ 14

10. Legs black, dorsum dark brown, eye-tubercle slightly spinulate *L. nigripes* Weed (Ohio)

Legs pale, sometimes marked with black 11

FIG. 5. — *Taracus pallipes.*

11. Femur I barely as long as body, tips of femora and tibiæ dark brown or black, eye-tubercle nearly smooth *L. formosum* Wood (E. States)

Femur I plainly longer than body, eye-tubercle spinulate, legs not so distinctly marked with black 12

12. Abdomen tapering behind, dorsum golden, base of femora not black. trochanters dark brown, of moderate size *L. verrucosum* Wood (N. Y.)

Abdomen rather short and broad, legs very long, small species . 13

13. Dorsum and trochanters light brown, bases of femora not black *L. bicolor* Wood (S. States)

Dorsum yellowish, trochanters and bases of femora black *L. speciosum* Bks. (Ala.)

14. Body short and broad, femur IV often black at base, small species *L. politum* Weed (E. States)

Body tapering behind, femur IV not black at base, larger species 15

15. Extremely spinose beneath, an impressed line on last ventral segment. large species . . . . . *L. flavum* Bks. (S. States)

Moderately spinose, rather granulate, no impressed line, moderate size . . . . . *L. ventricosum* Wood (E. States)

HADROBUNUS Banks :

Dorsum finely spinulate ; legs longer, in female not much marked with brown at tips of joints . . . . . *H. grande* Say (E. States)

Dorsum more smooth, with many small, round, pale spots ; legs shorter, more marked with brown *H. maculosum* Wood (S. States)

MESOSOMA Weed . . . . . *M. niger* Say (S. States, Neb., Dak.)

The Nemastomatidæ include three genera, which can be separated as below :

1. Mandibles longer than the body, projecting forward (Ischyropsalinæ) Taracus

Mandibles shorter than body, directed downward . (Nemastominæ) 2

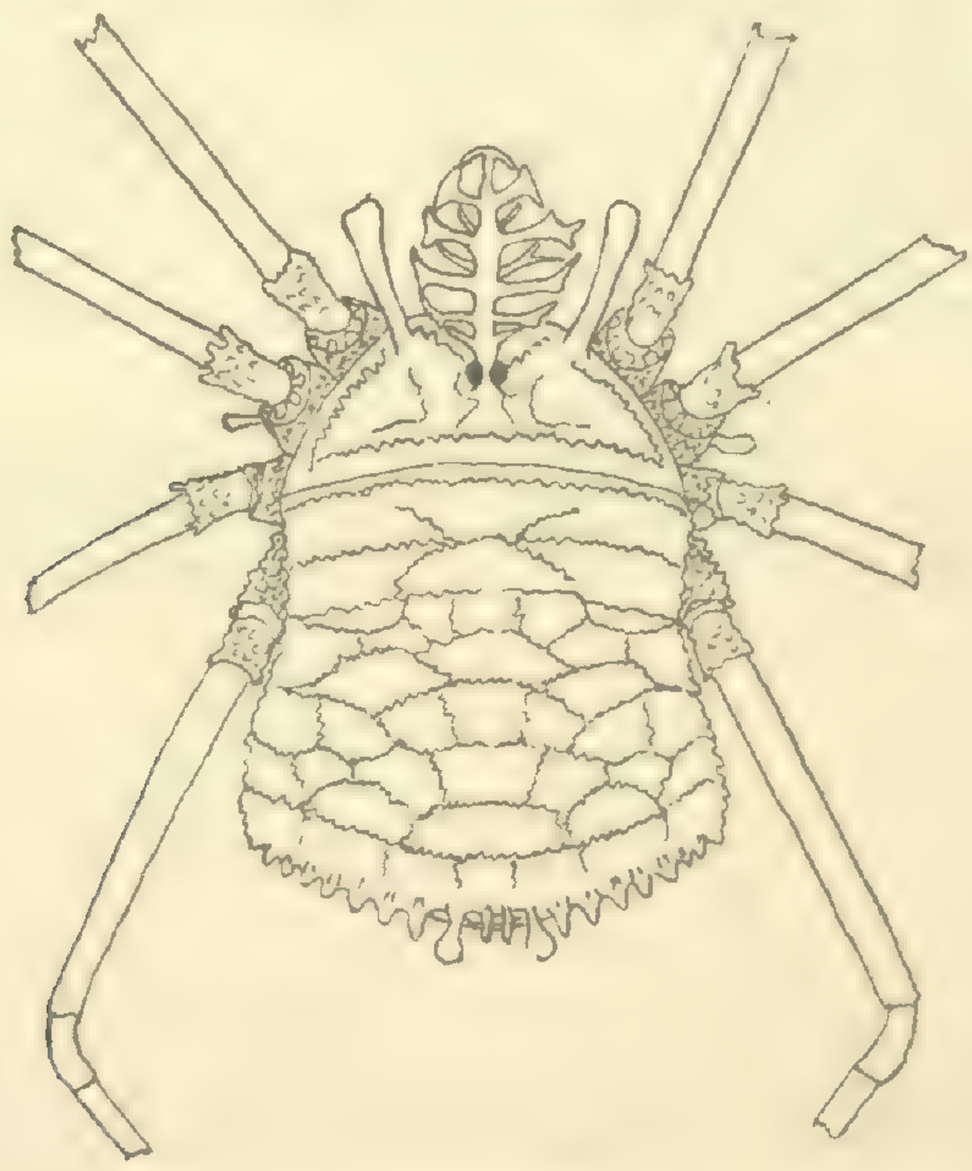


FIG. 6. — *Dendrolasma mirabilis*.

2. Fourth joint of palpus much thickened . . . . . Phlegmacera

Fourth joint of palpus scarcely thickened . . . . . Nemastoma

PHLEGMACERA Packard :

1. Several false articulations in femora III and IV, eye-tubercle very broad . . . . . *P. bryantii* Bks.[1] (Alaska)

No false articulations in femora 2

2. A pair of prominent erect spines on the anterior part of the abdomen . . . . . *P. occidentalis* Bks. (Wash.)

No such spines . . . . . *P. cavicolens* Pack.[2] (Ky., N. Y., N. H.)

[1] Includes *Tomicomerus bispinosus* Pavesi.

[2] Includes *Sabacon spinosus* Weed.

NEMASTOMA Latreille:

1. Fourth joint of palpus less than twice as long as the fifth
N. inops Pack. (Ky.)

Fourth joint of palpus twice as long as the fifth 2

2. Dorsum with some spines . . . . *N. modesta* Bks. (Calif., Wash.)
Dorsum without spines . . . . . *N. troglodytes* Pack. (Utah)

TARACUS Simon:

1. Dorsum of abdomen spinose, mandibles pale in color
T. spinosa Bks. (Calif.)

Dorsum of abdomen smooth, mandibles dark 2

2. Mandibles smooth . . . . . *T. pallipes* Bks. (Wash.)
Mandibles rough, very distinct spines on basal joint
T. packardi Sim. (Colo., N. Mex.)

The Trogulidæ in our fauna is represented by but two genera, both restricted to the Pacific slope:

1. Eye-tubercle projecting in the form of a spoon, two spines at each side on the anterior margin . . . . . Ortholasma

Eye-tubercle branched, a single club at each side on the anterior margin . . . . . Dendrolasma

ORTHOLASMA Banks . . . . . *O. rugosa* Bks. (Wash.)

DENDROLASMA Banks . . . . . *D. mirabilis* Bks. (Calif., Wash.)

PRINCIPAL WORKS ON PHALANGIDA.

BANKS, N. The Phalangida Mecostethi of the United States. *Trans. Amer. Ent. Soc.* Vol. xx (1893), pp. 149–152.

——— The Phalanginæ of the United States. *Can. Entom.* (1893). pp. 205–211.

——— The Nemastomatidæ and Trogulidæ of the United States. *Psyche* (1894), pp. 11, 12; 51, 52.

WEED, C. M. A Descriptive Catalogue of the Harvest Spiders (Phalangiidæ) of Ohio. *Proc. U. S. Nat. Mus.* Vol. xvi (1893), pp. 543–563, 12 pls.

——— New or Little-Known North-American Harvest Spiders. *Trans. Amer. Ent. Soc.* Vol. xix (1892), pp. 187–194, 7 pls.

WOOD, H. C. On the Phalangeæ of the United States of America. *Commun. Essex Inst.* Vol. vi (1868), pp. 10–40.

PRINCIPAL WORKS ON SCORPIONS, SOLPUGIDS, AND PEDIPALPI.[1]

KRAEPELIN, K. Revision der Scorpione. *Jahrb. Hamburg.* Teil I, Bd. viii (1891), pp. 1–144; Teil II, Bd. xi (1894), pp. 1–248.

——— Scorpiones und Pedipalpi. *Das Tierreich*, 8. Lieferung (1899), pp. 1–265.

PUTNAM, J. D. The Solpugidæ of America. *Proc. Davenport Acad. Nat. Sci.* Vol. iii (1882), pp. 1–149, 4 pls.

WOOD, H. C. Descriptions of New Species of North-American Pedipalpi. *Proc. Acad. Nat. Sci. Philadelphia* (1863), pp. 107–112.

——— On the Pedipalpi of North America. *Journ. Acad. Nat. Sci. Philadelphia.* (2.) Vol. v (1863), pp. 357–376.

[1] This list was omitted in Synopsis IX.

VARIATION NOTES. — Nos. 4–6.

4. **A Case of Polydactylism.** — A number of years since, a case of polydactylism attracted my attention, and in view of the value of

records of such cases I have decided to offer an account of the facts as known to me. The case was that of a young man twenty-five years of age, a student in Hamline University. The accompanying

drawings are tracings made by running a pencil around the outlines of the feet and hands. The right hand is entirely normal. The left hand varies as to the little fingers, there being two digits. A careful manipulation of the palm showed that there is a single metacarpal at the base, and distally two digits, each with three bones; the bones are entirely separate, though the skin grows across between them on the level of the proximal joint. Both of the feet are six-toed, the ulnar digit in each being doubled. This doubling was found, by feeling through the skin, to begin with the digit, the metacarpal being single. The left foot bears a lump on the outside at the base of the outer digit, seemingly due to an irregularity connected with the variation presented by the toes. I was told that it had been there from before the time of fitting the first pair of shoes. There was no knowledge of a similar condition of the digits in the family; the grandparents were personally known to the young man and nothing like it had been remarked among his relatives.

The case appears to fall in the class of cases noted by Bateson ("Materials for the Study of Variation," p. 345) as among the commonest forms of polydactylism, in which there is an extra minimus, the metacarpals and metatarsals being normal. H. L. OSBORN.

5. **Pedigree Mouse Breeding.**[1] — V. Guaita has bred white and walzing mice through seven generations. There has been a loss of fecundity, due to too close inbreeding. Tables are given showing the ancestry of about three hundred mice of varying colors. The author does not make sufficient use of his data. The most striking fact is that when pure-bred white mice were crossed with pure-bred walzers (chiefly black and white), all of the twenty-eight progeny were gray, or like a house mouse, and none were walzers. When these were bred together, nine color classes at once appeared, including albinos and walzers, as well as grays and gray-blacks. If the results of breeding in the later generations are compared with what one should expect from Galton's law of ancestral inheritance, it results that the albinos appear unusually stable and prepotent. On the other hand, the walzing condition seems to be unstable and to be less potent than normal.

[1] Von Guaita, G. Zweite Mittheilung über Versuche mit Kreuzungen von verschiedenen Hausmausrassen, *Berichte d. naturf. Ges. Freiburg*, Bd. xi, Heft 2, pp. 131–138, 1899.

6. **The Long-Tailed Field Mouse**[1] (*Mus sylvaticus*) has a distribution which is almost coterminous with the limits of the Palearctic Region; hence is a "wide-ranging species" in Darwin's sense. It is also an old species, for its bones are found in the cave deposits. It is much less variable than many other small mammals, and sports especially are rare. Thus it is a case against Darwin's law of the great variability of wide-ranging species and for Sedgwick's law of loss of variability in an old species. However, albinos (with pink eyes) have been noted as rare sports. The prevailing color is white below and more or less rufous above. Since the young are more like the house mouse in color, this color may be considered ancestral. The adult mouse becomes small and dark in certain isolated maritime localities (Lewis, Skye, Galway, and Kerry); a variation paralleled by that of squirrels, cattle, birds, the slugs, Limax, and butterflies. The mouse becomes rich-colored as it approaches the Oriental Region, — the home of rich-colored birds, — for example, at Kuatun. It is bright, clear-colored in the cold, drier regions of central Europe, just as the squirrel and red-backed vole are.

[1] Barrett-Hamilton, G. E. H. On Geographical and Individual Variation in Mus sylvaticus and its Allies, *Proc. Zoöl. Jour.*, pt. ii, pp. 387–428, London, August 1, 1900.

REVIEWS OF RECENT LITERATURE.

PHYSIOLOGY.

Heliotropism. — In this paper Holt and Lee [1] are chiefly concerned with a theoretic discussion of the nature of the responses of organisms to light ; but they present, also, in support of their theory, the results of some experiments with Stentor Cœruleus, a species of Lynceus, and some fresh-water planarians. The title of the paper, "The Theory of Phototactic Response," is misleading, since the term "phototactic" is used, not in the ordinary sense, but as including those responses which have been called photopathic. In the present state of our terminology "heliotropic" would be a better term.

Intensity of light and direction of ray have been championed for half a century as the important factors of light as a stimulus : at one moment "direction" has been emphasized, at another "intensity." The present writers maintain that light acts only by its intensity, the direction of the ray being a secondary factor and one, furthermore, of an entirely different nature. Their theoretic discussion centers about the views of two prominent physiologists, Loeb and Verworn ; and Verworn's theory is accepted as adequate for the explanation of all responses to light. Loeb is characterized as a believer in the importance of "direction," and Verworn in that of "intensity," but it is observed that their theories are not contradictory. So far as the exposition of these two theories, as given in the text, is concerned one seems just as applicable to the facts in question as the other, the only difference being that Loeb has sometimes used the term "direction" when intensity is evidently the determining factor, thus in appearance giving emphasis to the importance of direction, while Verworn has in all cases expressed himself in terms of intensity.

The facts of response to light, admitted as such by Holt and Lee, are three : (1) orientation in the axis of the ray, (2) positive or negative movement, (3) random movement. In explanation it is assumed that animals which show these three phases of reaction have

[1] Holt, Edwin B., and Lee, Frederic S. The Theory of Phototactic Response, *Amer. Journ. Physiol.*, vol. vi, pp. 460–481, January, 1901.

an optimum intensity in which they are not directed by the light but move at random. Below this is the sub-optimal and above it the supra-optimal. An animal in either the sub- or supra-optimal intensity is oriented by the rays so that symmetrical points of the body are equally stimulated; this is, of course, accomplished by the placing of the longitudinal axis of the organism in the axis of the ray. And whether an animal orients itself with head toward or away from the source of light (*i.e.*, whether it is positively or negatively phototactic) depends upon the physiological condition of the animal and the intensity of the light. By sub-optimal intensities organisms are supposed to be directed toward the light through the expansion of those motion-producing elements which are on the side most strongly stimulated; hence there results from this kind of orientation a positive reaction. The same organism, if in a supra-optimal intensity, will be oriented with head away from the light, because in this case contraction instead of expansion is caused, and the reaction will be negative. The orientation theory has been very clearly stated by both Loeb and Verworn.

Several different kinds of reactions, representatively selected, are explained by the writers by their theory; among them is the case of a positively phototactic animal moving toward the source of light into a less intensely illuminated region. This reaction has been taken heretofore as evidence of the independent influence of "direction" of ray. It is clearly shown in the present paper, however, that such a contention is probably false, for difference in intensity and the angle at which the organism strikes the side of the vessel are sufficient to explain the observed courses taken under such conditions.

That light acts through intensity alone is a conclusion which this paper makes plausible, but it scarcely justifies the unconditioned statement that it *does not* act by the course which the rays take through the organism. Such a reaction as the reversal of response observed by Towle in Cypridopsis and by Yerkes in Daphnia and Cypris is not easily explained by the hypothesis under consideration. The paper is valuable in that it makes clear the importance of intensity and at the same time indicates the danger of confusion in using direction as a causal term, although intensity does in part depend upon it.

R. M. Y.

Notes. — The chief defects of laboratory guides arise from the difficulty of giving sufficient directions to the student without supplying him with information that he should get from laboratory

study. This is the principal failing in Brown's *Physiology for the Laboratory* (Boston, Ginn & Co., 1900, viii + 167 pp.), which, however, is so well balanced in other respects that it deserves to be in the hands of the teacher if not in those of the pupil.

Kelly (*Jena. Zeitschr.*, Bd. XXXV, p. 429) has pointed out that calcic carbonate occurs in nature in five forms: calcite, aragonite, ktypeite, conchite, and amorphous calcium carbonate. Of these calcite and conchite are the only ones found abundantly in organisms. Conchite is probably slightly more soluble, harder, and has a higher specific weight than calcite. Both forms occur throughout the animal series; thus calcite is the mineral component of the shells of echinoderms, brachiopods, crustacea, bryozoa, of the calcareous spicules of sponges, of the ear stones of fish and amphibia, and of the eggshells of mollusks, most reptiles, and birds; conchite is characteristic of the skeletons of most stone corals, and the shells of many mollusks.

Steinach and later Magnus have shown that the iris of a frog's eye will contract when stimulated by light, even after the eye has been removed from the animal. Steinach believed this to be due to the direct action of light on the sphincter muscle; Magnus attributed it to a short nervous reflex arc within the eye. Guth (*Archiv ges. Physiol.*, Bd. LXXXV, p. 119) finds that frog eyes show this reaction fully two weeks after their removal from the animal,—a period much longer than that during which other organs containing reflex arcs, like the intestine, remain active. Moreover, pieces of the edge of the iris as well as minute isolated groups of muscle fibres from the sphincter pupillæ contract on illumination. As the latter were shown on microscopical examination to contain no ganglion cells, it must be admitted that Steinach's contention that the muscles of the iris are capable of being stimulated directly by light is correct.

BOTANY.

Recent Papers on Algæ. — (Comère, Joseph. *Les Desmidées de France*, Paris, 1901, 222 pp., 16 pls.) In the introduction the author states his double purpose in writing this work; first, to give as full an account as possible of our present knowledge of the desmids; second, a manual for the study and determination of the French

species. The first chapter deals with structure and physiology, the second with methods of collection, preparation, and study; then is a historical sketch, with bibliography, dealing with France only. Chapter 4 occupies the greater part of the book, giving the general principles of classification, followed by description of all known French species and forms. A table showing the distribution in the different provinces of France and a list of all works cited complete the text. There are sixteen plates, containing over eight hundred figures.

It is somewhat singular, considering how much of our best algological work is done by French writers, that there has never been any general systematic work on French algæ, such as Harvey's *Manual* or *Phycologia* in Great Britain, Hauck's *Deutsches Meeresalgen* in Germany, and similar works in other countries. This seems to be the first work treating of algæ, covering the whole of France, and giving descriptions of all the species mentioned. It must certainly be of much use to French students.

The classification follows in general that used by De Toni in the *Sylloge Algarum*, but with some modifications. The tribe Docideæ is united with the Closteriæ, while the Micrasteriæ retain only the forms with chromatophores as parietal disks, the forms having radial chromatophores forming the tribe Cosmariæ. The form of the chromatophores is recognized as of value in classification, but the author does not give it the value attributed by Gay.

A scientific work written by a Frenchman always has one great advantage, the "inexorable clearness" of the language; moreover, a French author apparently does not feel that a good style of writing will cast doubts on his scientific thoroughness or soundness. These merits the work in question has, and also the French predilection for symmetry; the description is a description, the note a note, and one does not run into the other; history does not intrude into physiological discussion, nor bibliography into directions for collecting.

The plates are clear, every species described being represented, mostly by camera drawings by the author. In nearly every case a colored figure is given to show the appearance of the living plant, and a line drawing to show the markings of the empty cell. Only two scales of magnification are used, 200 and 300, and the same scale is used in all the species of a genus, which is very convenient for comparison. There is an index, both of accepted names and of synonyms.

The descriptions are sufficiently full, and appear to be accurate; occasionally a word is used in a sense that might be misleading, as on p. 21, where certain desmids are said to occur "en parasites," on Sphagnum, etc. Full references are given to French authors, and a considerable number to foreign works, but the English language seems to offer great difficulties to M. Comère, as it has to many others of his nation. There are many references to Wolle's *Desmids of the United States*, and this work, with three papers published in the *Torrey Bulletin*, appears in the bibliography. It is fair to assume that M. Comère must have seen the book, but both in references and bibliography the name is "Woole." Quite curiously, at p. 98 there is a reference to another *Torrey Bulletin* article, which does not appear in the bibliography, and in this one place the name is properly spelled, "Wolle." "*Dysphynctium Thwatesii*," with synonym "*Calocylindrus Twatesii*," at p. 92, and "Twaites," p. 130, represent three attempts on the name of a well-known botanist. "Barcker in Quartely Journal, p. 208," is an interesting combination. A certain amount of carelessness in proofreading is noticeable here and there: in the bibliography Reinsch is followed by a period, as if an abbreviation, while Schaarschm has no period, though it represents Schaarschmidt. Sutarastrum, *Closterium monoliferum* are similar cases. But let him that never overlooked an error on a proof-sheet cast the first stone at M. Comère.

The work makes no innovations and does not claim to add largely to previous knowledge, but it puts in small compass, and in shape convenient for the student, what otherwise would have cost him much time and trouble. Any work doing this is valuable. The nomenclature is eminently conservative; no new species is proposed, nor is any one transferred from one genus to another; the author must have nobly resisted the temptation to attach his name to something.

(Kjellman, F. R. "Om Floridé-Slägtet Galaxaura dess Organografi och Systematik," *Kongl. Svenska Vetenkaps Akademiens Handlingar*, Bandet XXXIII. Stockholm, 1900. 109 pp., 20 pls.) The genus Galaxaura, of which this paper treats, has its home in tropical and subtropical waters, the broad belt occupied by it extending quite around the world, its northern limits being near the straits of Gibraltar and on the coast of Florida in the Atlantic, Mexico and Japan in the Pacific. In the southern hemisphere it reaches similar latitudes.

In Engler and Prantl's *Naturfamilien Pflanzen* the genus is noted as having about twenty species, many of them little understood. In examining the forms from Japan, collected by the Vega expedition and subsequently by Petersen, Dr. Kjellman found many that could not be placed under known species, and was led to make a thorough study of the genus. The result of this study may be seen in the fact that, of the sixty-two species here recorded, only sixteen are of previous authors; the remaining forty-six are new.

Habit characters, on which the previous classification was almost entirely based, are here considered as of little value, and structural characters are used instead, the descriptions being supplemented by nineteen quarto plates of anatomical drawings by the author, while a double plate gives habit figures, photographically produced from herbarium specimens. The rich collections of Areschoug, Agardh, and the author himself, with those in the Swedish museums, formed the material on which the work is based, and the fact that it was all dried material in herbaria constitutes the one possibly weak spot in the results. The ideal method of study would be to see all the species in their homes, to notice the range of variation of a species in different local conditions and at different seasons, and then, with the results of this study clearly in mind, to refer to the original types. But when this study of living material must be made over half the surface of the globe, or at least the seacoast within that area, it is evident that this ideal is hardly likely to be attained.

In the tables showing the distribution of the species, only three are assigned to the coast of the United States, *G. flagelliforme*, *G. stellifera*, *G. umbellata*. This number will have to be increased, as on the shores of Florida there occur *G. obtusata*, *G. rugosa*, *G. lapidescens*, and *G. marginata*. The last two species, in the older sense, are divided by Kjellman into several species each, so that the figure for our coast must be seven, and may be one or two more.

The descriptions of the new species and the explanations of the plates are in Latin; the rest of the work, including all the historical notes and the anatomical studies, are in Swedish, which is unfortunate in a work of such general scope and interest.

(Svedelius, Nils. "Studier öfver Östersjöns Hafsalgflora," *Akademisk Afhandling*. Upsala, 1901.) The author has made a careful study of the red, brown, and green algæ of the eastern and northern part of the Baltic Sea. The flora is quite a limited one, only fifty-six species being enumerated, there being a steady falling off in the

number of species to be found as we pass from the German Ocean and along the Baltic to the Gulf of Bothnia. There is a steady reduction in the saltness of the water in this direction until at last it is almost imperceptible. Moreover, the east and west sides of the Baltic have differing degrees of salinity, and sudden changes in this, as also in the temperature, are produced by winds, conditions quite unfavorable to the existence of most marine algæ; hence the poverty of the flora.

Two elements appear to compose the flora, an Atlantic and an Arctic, but without any sharp division line. Four species, one of them new, *Ascocyclus affinis*, are considered endemic, thirty-five are characteristically Atlantic, seventeen characteristically Arctic. Most of the species appear in somewhat reduced or depauperate forms, in comparison with normal conditions. This is not the case with the green algæ, however, which are fully as well developed as elsewhere; not unnaturally, as the green algæ are largely fresh-water plants, the red and the brown being specially marine. As in the Arctic regions, some species cover considerable areas of bottom in loose-lying masses, not attached to any substratum, new growth continually forming as the old decays. These detached individuals are uniformly sterile, as is the case in the Arctic Sea, and also with the vast floating masses of Sargassum in the Atlantic. Green algæ are predominant in the upper littoral region, brown in the lower littoral, and red in the sublittoral, in about the same proportions as in the Atlantic.

There are a number of illustrations, mostly habit illustrations, among them a number of forms of *Fucus vesiculosus*, and transitions between forms; since names have been given these forms, it is perhaps well to illustrate them, but it is doubtful if they can be considered as at all well defined. It is usual to include under *F. vesiculosus* all diœcious forms with vesicles, as well as those that look as if they ought to have vesicles. It is not unlikely that more than one species may be here included, but we are not yet in a position to draw the lines.

The work is in Swedish, which is perhaps natural under the circumstances of its issue, but like Kjellman's work previously noted, it is not easy of use by the majority of botanists.

(Børgesen, F. *Freshwater Algæ of the Færöes.* From the *Botany of the Færöes.* Copenhagen, 1901.) Together with Mr. Borgesen's paper on the algæ, there are printed E. Warming's "Historical

Notes on the Botanical Investigation of the Færöes," and C. H. Ostenfeld's "Notes on Geography, Climate, Topography, Geology, and Industrial Conditions." Mr. Ostenfeld's notes are furnished with excellent illustrations, so that we reach Mr. Børgesen's list of the algæ with a good understanding of the conditions that have made the flora what it is. This flora must have been introduced since the last glacial epoch, and, according to the writer, it is probably more than anything else the birds that have gradually contributed the various fresh-water algæ found on these eighteen rocky islands, only five of which have an area of over 100 kilometers each. In their migrations through Great Britain to the Arctic region the birds make a stop on these islands, the distance from the northernmost British isles being only a two hours' flight. So we find two elements in the Færöe flora, a southern, agreeing with that of Great Britain, and including some forms supposed to be peculiar to the latter, and an Arctic element; the one brought by the spring migration, the other by the return in autumn.

In all, 323 species are enumerated, beside many varieties and forms. The desmids, with 175 species, constitute more than half of the whole, — the other green algæ number 103; there are forty-one Cyanophyceæ; one Nitella, one brown alga, *Hydrurus fœtidus*, and one red alga, *Chantransia hermanni*, complete the list.

Two species of Enteromorpha, *E. compressa* and *E. micrococca forma subsalsa*, were found in brooks at a height of 200–300 meters. The former has been considered exclusively marine, the latter has been found in brackish pools in the Arctic regions; their occurrence in running fresh water is quite noteworthy. Beside several new varieties and forms, two new species are described, *Euastrum lyngbyei* and *Cladophora lyngbyei*; a plate of the latter, however, shows a form of branching which hardly accords with Cladophora; it would seem as if the plant belonged rather in Siphonocladus.

There are four good plates and an excellent map, and the whole is in unexceptionable English.

(Hirn, Karl E. "Monographie und Iconographie der Oedogoniacien," *Acta Societatis Scientiarum Fennicæ*. Helsingfors, 1900.) This volume of 400 quarto pages and sixty-four plates is a notable addition to the working tools of the systematic algologist. One hundred and ninety-nine species of Œdogonium, forty-four of Bulbochæte, and one of Œdocladium are composed in the family. Full diagnoses of all the species, with their many varieties and forms, are

given in Latin, and there is an elaborate key to the species in the same. The detailed notes under the species, as well as the general chapters, are in German. These general chapters give a full résumé, with illustrations in the text, of the structure, development, and physiology of the Œdogoniaceæ. Description, measurements, synonyms, and localities are given in ample detail, and the plates represent all the species and forms. The figures are in outline, and were drawn by the author from nature; all are of the same scale, 300/1, except a few details requiring a higher scale, and one habit figure of Œdocladium. This uniformity of scale is a great convenience in actual use of the work.

The standard work on this family has been Wittrock's *Prodromus Monographiæ Œdogoniearum*, published in 1874. In this are represented 140 species, but only a single plate, of general types, accompanied the work. In a family like this, where the vegetative characters are of great simplicity, the need of accurate figures increases even more rapidly than the number of species: the best of descriptions are insufficient. So that, though De Toni's *Sylloge Algarum* gives descriptions of all species published up to 1889, it is extremely difficult to determine species by it. Dr. Hirn had the advantage of study with Wittrock and Nordstedt, had opportunity to examine type specimens of nearly all species, and had been receiving material from collectors in all parts of the world for a number of years. As a result, the list of habitats includes all parts of the earth; even South America, generally an algological *terra incognita*, being quite well represented. North America, though with few exclusive species, shows quite a rich flora, but the author wisely places a (?) against those references in Wolle which he has not been able to verify by authentic specimens. Of the 244 species, forty-five are described here for the first time.

F. S. Collins.

Notes. — *Biltmore Botanical Studies* is the title of a new journal of botany embracing papers by the director and associates of the Biltmore herbarium, the first number of which was issued on the 8th of April. It is published at Biltmore, N. C. The first number contains a revision of the species of Marshallia and descriptions of a considable number of new species of other genera.

Fascicle 1 of Vol. II of *Plantæ Bakerianæ*, by Professor E. L. Greene and others, covering fungi to grasses of Mr. Baker's collections of 1899, has been issued under date of March 11.

The first part of the "Illustrations of the botany of Captain Cook's voyage round the world in H.M.S. *Endeavour*, in 1768–71," by Banks and Solander, with determinations by James Britten, recently issued by order of the Trustees of the British Museum, contains one hundred folio plates representing Australian plants.

Parts II and III of Mr. F. Manson Bailey's *Queensland Flora*, published under the authority of the colonial government, have been issued and cover the orders Connaraceæ to Gentianaceæ, inclusive.

A new edition of Pond and Clements's *Phytogeography of Nebraska* has been brought out. Only one hundred copies are offered for sale, and as the work possesses real and general merit, though its purpose is local, the edition is likely to be soon exhausted.

Dr. Holm publishes a fifth list of additions to the flora of Washington, D. C., in the *Proceedings* of the Biological Society of that city, under date of April 2.

A supplement to *The Flora of the Upper Susquehanna and its Tributaries*, by Willard N. Clute, is published by the author at Binghamton, N. Y., under date of February 15.

The opening part of Vol. XV of the *Transactions of the Linnæan Society* consists of a report on botanical collections from Mount Roraima, in British Guiana.

An article on the determination of the type in composite genera and species, by President Jordan, appears in *Science* for March 29.

A paper on the Ranunculaceæ of Iowa, by T. J. and M. F. L. Fitzpatrick, is reprinted from the *Bulletin* of the laboratory of natural history of the University of Iowa.

The germination of *Bertholletia excelsa* is described in a well-illustrated article by William Watson, of Kew, in the *Annals of Botany* for March.

A paper dealing with American plants that is likely to be overlooked is E. H. L. Krause's "Nova Synopsis Ruborum Germaniæ et Virginiæ," the first part of which was published by the author in 1899 at Saarlouis.

In an account of a collection of Cratægus from near Montreal. made by Mr. Jack, Professor Sargent, in *Rhodora* for April, describes six additional new species.

Dr. Rydberg describes further new Potentillas in the *Bulletin of the Torrey Botanical Club* for March.

Eupatorium boreale is the name proposed in *Rhodora* for April by Professor Greene for what commonly passes in New England as *E. ageratoides.*

The genus Teucrium, as it is represented in the eastern United States, is passed in review by Bicknell in the *Bulletin of the Torrey Botanical Club* for March.

A supposedly new horse gentian is described from the northern states by Bicknell, under the name *Triosteum aurantiacum*, in *Torreya* for March.

Miss Eastwood describes some small-flowered Nemophilas from the Pacific coast in the *Bulletin of the Torrey Botanical Club* for March.

Engler's *Botanische Jahrbücher* of March 12 contains a paper by Lopriore on the geographical distribution of Amarantaceæ with reference to their relationships.

Pentstemon heterophyllus is illustrated in the *Revue Horticole* of April 1.

Aloe Lynchii, an artificial hybrid between *Aloe striata* and *Gasteria verrucosa*, is figured in the *Gardeners' Chronicle* of March 30. As with most bigeneric hybrids, this is a cross between representatives of genera which, though logically separable, are capable of treatment as sections of a single genus.

A number of new or little known grasses are described in *Circular No. 30* of the Division of Agrostology of the United States Department of Agriculture.

A portrait of Mr. George E. Davenport appears as the frontispiece to *The Fern Bulletin* for April.

Several American species of Cypripedium are photographically illustrated in *Die Gartenwelt* of March 16, in an article on their cultivation.

Poisoning by the pileate fungi, which has recently been exhaustively treated by Gillot in a thick volume published by the house of P. Klincksieck of Paris, is the subject of a number of recent notes in the *Bulletin de la Société des Naturalistes de l'Ain.* Of 222 cases of poisoning, the records of which were examined by Gillot, 86 resulted fatally, and of these 2 were doubtful and the other 84 were due to Amanitas or Volvarias.

Professor Peck's quarto plates illustrating the edible fungi of New York, with a number of additional plates and revised letter-press, have been issued as Vol. IV, No. 3, of the *Memoirs of the New York State Museum.*

A study of *Boletus luteus*, deformed by the parasitic *Hypomyces chrysospermus*, by Van Bambeke, appears in the recently issued *Bulletin de la Société Royale de Botanique de Belgique* for 1900.

A new species each of Tolyposporium and Ustilago in the ovaries of *Eriocaulon septangulare*, from Massachusetts, is described by Clinton in *Rhodora* for April.

The cambial slime diseases of trees are being rediscussed by Dr. Holtz in current numbers of the second Abteilung of the *Centralblatt für Bakteriologie*, etc.

Dr. E. F. Smith has published an extended and well-illustrated résumé of what is known of bacterial plant diseases, in recent numbers of the *Centralblatt für Bakteriologie*, Abteilung 2.

A paper on the organography and taxonomy of Galaxaura, a genus of red algæ, by Kjellman, is separately issued from the *K. Svenska Vetenskaps-Akademiens Handlingar*, Vol. XXXIII, No. 1.

Nowhere have ecological facts found so good exposition in gardening as at the Berlin botanical garden, where, from the moment of assuming the direction of the establishment, Dr. Engler has devoted himself to a development of this most important museum feature of a botanical garden. One of the most instructive of recent treatises on the ecological distribution of plants is issued as Appendix No. 7 to the current volume of the *Notizblatt* of the Berlin garden, and consists in a terse logical analysis of the plant formations of the Alps as exemplified in the newly established garden at Dahlem.

An extensive and well-illustrated treatise on the dissemination ecology of Scandinavian plants, by Dr. Rutger Sernander, is distributed from the University of Upsala, and forms an octavo of over 450 pages, the Swedish text being accompanied by a German summary.

A good example of what Huth has called stem-fruiting plants is given in a plate of *Artocarpus integrifolia*, published by Dr. Wilcox in the *Proceedings of the Columbus Horticultural Society* for 1900.

R. E. B. McKenney publishes some illustrated ecological notes on plant distribution in the *Beihefte zum Botanischen Centralblatt*, Bd. X, Heft 3.

Dr. Clements, of the University of Nebraska, is to conduct a class in field ecology in the higher mountains of Colorado next summer, extending through the months of July and August. The class should be large and enthusiastic.

The photosynthetic activity of chlorophyll occurring below corky tissue in the stems of several plants is discussed by Mlle. Goldflus in the *Revue Générale de Botanique* of February 15.

The apparatus of transpiration, or sudation, as the author prefers to call it, is discussed by Goffart in Vol. XXXIX of the *Bulletin de la Société Royale de Botanique de Belgique.*

"The Indian doctor's dispensatory, being Father Smith's advice respecting diseases and their cure, by Peter Smith of the Miami country," published in Cincinnati in 1812, is reprinted as No. 2 of the "reproduction series" of the *Bulletin of the Lloyd Library.* It is accompanied by a biography by John Uri Lloyd.

A neat little book on alpine plants and their cultivation, by W. A. Clark, has been brought out for the author by L. Upcott Gill of London and Charles Scribner's Sons of New York. It is illustrated by a number of exquisite half-tones showing some of the choicer species as grown in artificial rockeries.

Portraits of a number of the American botanists of the last two centuries are published in the recently issued second part of the *Report of the U. S. National Museum* for 1896–7.

PUBLICATIONS RECEIVED.

(Regular exchanges are not included.)

ARNOLD, AUGUSTA FOOTE. The Sea Beach at Ebb Tide. A Guide to the Study of the Seaweeds and the Lower Animal Life found between Tide Marks. New York, Century Company, 1901. x, 490 pp., 8vo, 85 pls., and many text-figs. $2.40. — ATKINSON, J. F. First Studies of Plant Life. Boston, Ginn & Company, 1901. xii, 266 pp., 8vo, 308 figs. — *Bibliographia Physiologica.* Vol. i, vol. ii, Nos. 1, 2. Turici, Concilii Bibliographici, 1898–99. — COMÈRE, J. Les Desmidices de France. Paris, Paul Klincksieck, 1901. 222 pp., 8vo, 16 pls. — DICKERSON, MARY C. Moths and Butterflies. Boston, Ginn & Company, 1901. xviii, 344 pp., 8vo, 233 figs., mostly photographs from life. — FRIEDLAENDER. Zoologisches Adressbuch. Teil ii. Berlin, R. Friedlaender & Sohn, 1901. viii, 517 pp., 8vo. 6 marks. — GANONG, W. F. A Laboratory Course in Plant Physiology, especially as a Basis for Ecology. New York, Henry Holt & Co., 1901. vi, 146 pp., 8vo, 35 figs. — HERRICK, F. H. The Home Life of Wild Birds. New York, Putnams, 1901. xix, 148 pp., 8vo, 130 figs. $2.50. — HOWARD, L. O. Mosquitoes: How they Live; How they Carry Disease; How they are Classified; How they may be Destroyed. New York, McClure, Phillips & Co., 1901. xv, 241 pp., 8vo, 50 figs. — MACDOUGAL, D. T. Practical Text-Book of Plant Physiology. New York, Longmans, Green & Co., 1901. xiv, 352 pp., 8vo, 159 figs. — SARS, J. O. An Account of the Crustacea of Norway, etc. Vol. iii, Cumacea. Pts. ix, x, Anatomy, Development, Supplement. Bergen Museum, 1900. x, pp. 93–115, Pls. LXV–LXXII. — SCHMEIL, O. Text-Book of Zoölogy treated from a Biological Standpoint. Translated from the German by Rudolf Rosenstock. Edited by J. T. Cunningham. London, Adam and Charles Black, 1901. xvi, 493 pp., 8vo, numerous illustrations. $4.00. — SEELIGER, O. Tierleben der Tiefsee. Leipzig, Engelmann, 1901. 49 pp., 8vo, 1 col. pl. 2 marks. — WRIGHT, MABEL OSGOOD. Flowers and Ferns in their Haunts. New York, Macmillan, 1901. xix, 358 pp., 8vo, illustrated. $2.50.

CHESTNUT, V. K., and WILCOX, E. V. The Stock-Poisoning Plants of Montana. U. S. Dept. Agr., Div. Bot., *Bull. No. 26.* 150 pp., 36 pls. — COQUILLETT, D. W. A Systematic Arrangement of the Families of Diptera. *Proc. U. S. Nat. Mus.* Vol. xxiii, pp. 653–658. — CORBETT, L. C. Sprayings. Results of Season 1900. *Bull. No. 70,* W. Va. Agr. Exp. Sta. Pp. 353–382, 17 figs. — DURY, C. A New Colandrid from Cincinnati, Ohio. *Journ. Cin. Soc. Nat. Hist.* Vol. xix, No. 8, pp. 243, 244, 1 fig. — FRAPS, J. S. The Nature of Pentosoids and their Determination. *Bull. No. 178,* N. C. Agr. Exp. Sta. Pp. 63–74. — GESTRO, R. Catalogo Sistematico dei Paussidi. *Ann. Mus. Civico Stor. Nat. Genova.* Vol. xv, 42 pp., figs. — GESTRO, R. Materiali per la Conoscenza della Fauna Erètrea Raccolti dal Dott. Paolo Magretti. *Ann. Mus. Civico Stor. Nat. Genova.* Vol. xx, 6 pp. — GIDLEY, J. W. Tooth Characters and Revision of the North American Species of the Genus Equus. *Bull. Amer. Mus.*

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IN THEIR WIDEST SENSE

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THE COMPOUND AND MIXED NESTS OF AMERICAN ANTS.

WILLIAM MORTON WHEELER.

PART II (*continued*).

V. DULOSIS.

UNDER this heading we may include all those remarkable mixed nests which owe their origin to the enslavement of one species of ant by another. This condition is characterized by Wasmann ('**91**, p. 43) as follows: "Here ants of different species dwell together, not only on the same spot, but coalesce to form one colony, a single social whole. In such communities the unity of the colony is of paramount importance, and the specific differences between the various components of the colony lapse so far into abeyance that they appear to be non-existent; the consociating ants, belonging originally to different nests, behave towards each other as if they were kith and kin, and carry on in common the construction of the nest, the acquisition of food, the education of the offspring, the defense of the nest, etc., so far as this is permitted by their physical and psychical endowments and the law of the physiological division

of labor. Hence the term 'slaves' is much less appropriate than the term 'helpmates' (auxiliaries)."

While the various forms of social symbiosis hitherto considered may exist between ants belonging to very different taxonomic subfamilies, dulosis is known to occur only between species of the same subfamily. This rule is based on but few cases, for only four genera, two belonging to the Camponotinæ and two to the Myrmicinæ, *viz.*, Formica, Polyergus, Strongylognathus, and Tomognathus, are known to contain dulotic species. Still it seems obvious that such close symbiotic relationships as those under consideration could be entered into only by species of very similar habits and phylogenetic derivation.

With the exception of Strongylognathus, the above-mentioned genera are all known to occur on our continent, the dulotic species of Formica (*F. sanguinea* Latr.) and Polyergus (*P. rufescens* Latr.) being represented by distinct races, or subspecies, the genus Tomognathus by a distinct species (*T. americanus* Emery). So little attention, however, has been devoted to our ants, that we may yet look forward to the discovery of an American Strongylognathus, for there are in America several species of the genus Tetramorium (including the subgenus Xiphomyrmex) which are allied to the *Tetramorium cæspitum* auxiliary of the European Strongylognathus.

The meagre work which has been done on our American dulotic ants is barely sufficient to show that their behavior is essentially like that of their European allies. Since these ants in America select their auxiliaries, or slaves, from a slightly different though allied ant fauna, we may yet expect to find some interesting differences in the details of habit and behavior.

Before enumerating the American species, together with their auxiliaries, it will be convenient to present a much condensed résumé of the splendid accounts of the European observers, Forel, Waşmann, and Adlerz.

Formica sanguinea Latr. — This species is a true Formica, which is sometimes found living without auxiliaries. It has broad, toothed mandibles, of the type characteristic of its

genus, and is naturally carnivorous, though it has been observed to attend aphides for the purpose of collecting their sugary excrement. Although this ant is, therefore, quite able to exist alone, it nevertheless has a very pronounced *penchant* for robbing the larvæ and cocoons of other species of Formica, eating great numbers of them but allowing others to develop and to function as its slaves, or auxiliaries. The latter feel themselves to be members of the colony in which they emerge from their cocoons, and direct all their activities to maintaining and defending their foster nest and its occupants. In Europe, as a general rule, the normal slaves of *F. sanguinea* are the workers of *F. fusca*, less frequently the workers of *F. rufibarbis*. Sometimes both species of auxiliaries may be found in the same mixed nest. In extremely rare instances the workers of *F. rufa* and *F. pratensis* may serve as slaves. The expeditions for robbing cocoons are usually carried out during July and August, but they seem to be rather infrequent or irregular and are not often observed. The tactics of *F. sanguinea*, like those of other dulotic ants, consist in surprising the colony they wish to rob and in carrying away the pupæ as rapidly as possible without engaging in unnecessary slaughter. Only the ants that offer active resistance are dispatched.

F. fusca is most frequently enslaved because it is a weaker and more tractable species and forms smaller colonies than *F. rufibarbis*. The rare occurrence of *F. rufa* and *pratensis* in *sanguinea* nests is due to the more savage nature of these species, which are enslaved only when they belong to small colonies or when they are of small size individually.

The number of auxiliaries in nests of *sanguinea* varies greatly. In Holland, in more than 100 nests, Wasmann ('91) found the ratio of *sanguinea* to slaves varying between 1:0 and 1:3. Most frequently the *sanguinea* are from 2 to 5 times as numerous as their slaves. The number of the latter depends on various circumstances, such as the abundance or scarcity of nests of the auxiliary species in the vicinity. It is a singular fact that the weakest colonies of *sanguinea* contain the greatest number of slaves, so that it would seem as if the dominant species tried to make good the deficiency in the

number of its workers by importing and employing foreign labor. This may result naturally from the fact that in weak colonies on an average a larger percentage of the stolen pupæ are permitted to develop into slaves. In populous *sanguinea* colonies, on the other hand, a considerable portion of the prey is devoured even when there is plenty of other insect food within reach.

The relations implied by the terms "slave" and "master" do not adequately express the conditions existing in these mixed nests, since *sanguinea* works side by side with its auxiliaries, which are neither a mere luxury nor an absolute necessity. Still, although *sanguinea* is capable of excavating and maintaining its own nest, the auxiliaries appear to be more enthusiastic and skillful workers in the earth. And although *sanguinea* looks after its own brood and the hatching of the cocoons of the auxiliary species, it must, nevertheless, derive some advantage from the assistance of its slaves. The latter, moreover, bring into the nest a good deal of food from the aphides, which they assiduously attend.

F. sanguinea, on moving to a new nest, usually carries its slaves, and is rarely carried by them. This is probably due to the fact that the *sanguinea* are of a more excitable temperament and therefore have a greater tendency to take the initiative in a change of dwelling than their more stolid auxiliaries.

Continental authorities uniformly maintain that the *sanguinea-fusca* nests contain only workers of the auxiliary species. In England, however, Rev. T. D. Morice ('00, p. 98) recently found a nest which contained also *fusca* males and queens in addition to the workers of this species. This very exceptional condition would seem to have arisen either from the failure of the *sanguinea* to consume all the pupæ of the fertile sexes of *fusca*, or less probably from the formation of an alliance colony between fertile queens of *sanguinea* and *fusca*.

Polyergus rufescens Latr. — The "amazon," as the paragon of dulotic ants, has been observed with great care by a number of investigators, among whom Pierre Huber ('10) and Forel ('74) hold the first place. It is a rather large, brown-red ant, allied to Formica, but characterized by the possession of slender,

sickle-shaped mandibles, the cutting edges of which are furnished with minute serrate teeth. Such mandibles are beautifully adapted to fighting, but scarcely fitted for the many other uses to which these organs are put by most ants. Polyergus is therefore a warrior, and on this account its life presents two very different phases, one replete with the brilliant tactics whereby it gains possession of the larvæ and cocoons of its

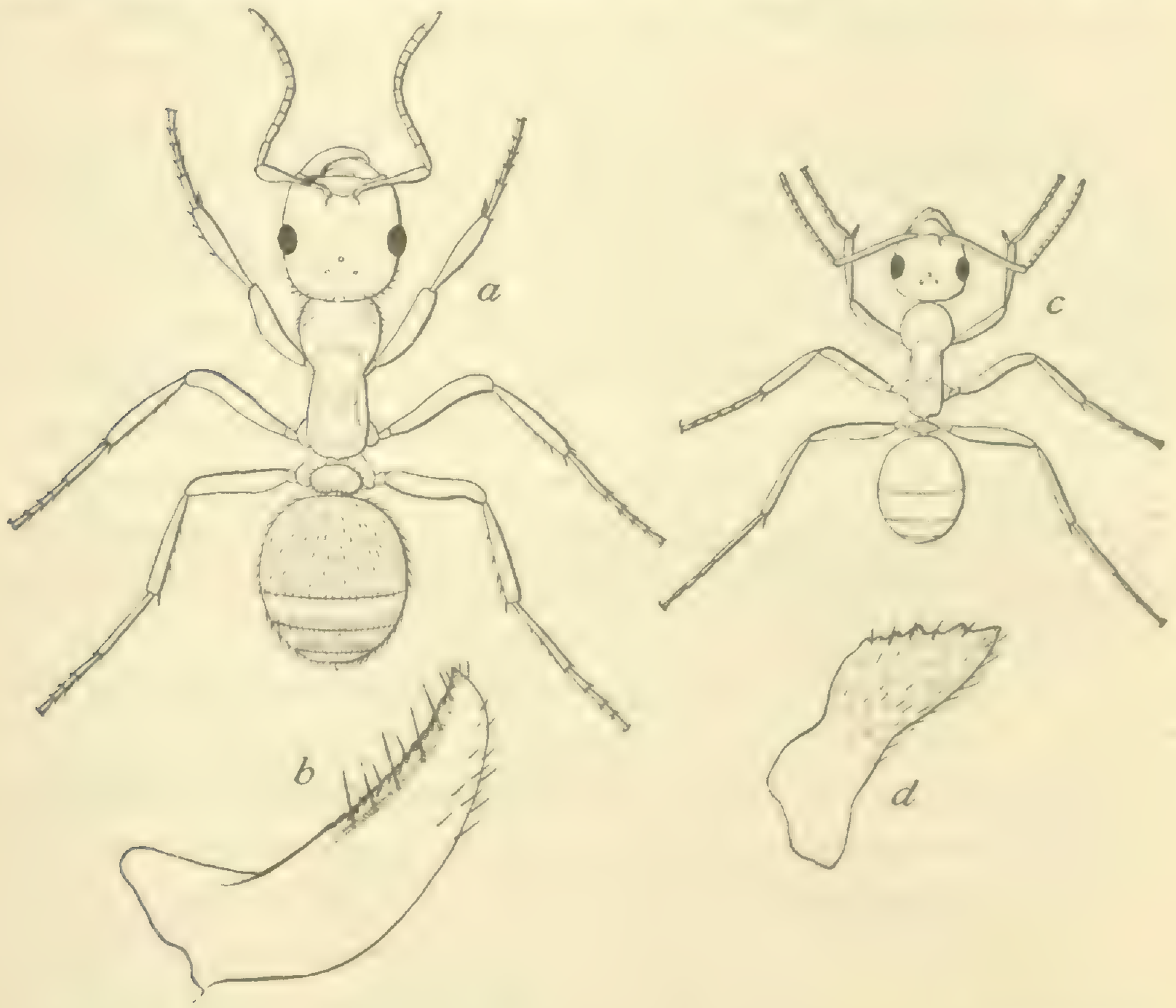

FIG. 15.—*a.*, *Polyergus rufescens* Latr., subsp. *breviceps* Emery, worker; *b.*, mandible of same; *c.*, *Formica fusca* L., var. *subsericea* Say, subvar.; *d.*, mandible of same.

slaves, the other characterized by abject helplessness and complete dependence on these same auxiliaries.

The auxiliaries of Polyergus are furnished by the very same species as in the case of *F. sanguinea*. In this case, also, *F. fusca* is most often victimized, *rufibarbis* less frequently. Occasionally, too, both species are found in the same nest. The number of slaves, however, is much greater than in *sanguinea* nests, being about seven-eighths of the entire colony. The dulotic expeditions of Polyergus have been often observed

since the days of Pierre Huber ('**10**, p. 210 *et seq.*). They have been admirably described by Forel ('**74**), who has also estimated (pp. 320, 321) the number of expeditions undertaken by a single powerful colony of these ants during a single summer. In thirty days (from June 29 to August 18, 1873) he witnessed forty-four expeditions of the amazons. These usually occurred between 2 and 5 o'clock P.M., the time limits being from 1.30 to 6 P.M. Among the forty-four expeditions there were forty-one attacks, nineteen on *fusca* and nineteen on *rufibarbis*, and three of which only the return was observed. The total number of cocoons robbed was estimated at 29,300 (14,000 *fusca*, 13,000 *rufibarbis*, and 2300 of unknown origin but probably *fusca*). Counting in the expeditions after August 18, which he was unable to witness, Forel concludes that not far from 40,000 larvæ and pupæ of the auxiliary species were appropriated during the summer of 1873 by a single Polyergus colony! Most of the pupæ were consumed, so that few of them ever hatched and became auxiliaries. And although two species were pillaged the colony later became almost entirely *F. fusca*.

Wasmann ('**91**, pp. 61, 62) has observed that the *fusca* auxiliaries are noticeably fiercer and more courageous than when nesting alone. The same is true of *fusca* in *sanguinea* nests. This is explained by Wasmann as merely a special case of the general rule that all ants are more courageous when they feel themselves backed by numbers.

The shadow side of the life of Polyergus is seen within its nest, where it is abjectly dependent on its slaves. Here it spends most of its time preening its legs and antennæ, as it is quite unable to excavate. On this account the character of the nest architecture is entirely determined by the auxiliary species. Moreover, the conformation of its mandibles is such that Polyergus cannot care for its own young or the pupæ of its slaves, though it sometimes licks the newborn callows. After a minute investigation of the question as to whether Polyergus is able to feed itself, Wasmann concludes that it can lap up liquids but is usually fed by the slaves. This mode of obtaining its food is, in fact, so essential, that it dies of starvation when deprived of its helpmates.

Polyergus goes on its cocoon-robbing expeditions unattended by its auxiliaries. When the colony moves to a new nest the Polyergus are nearly always carried by their slaves (*cf. F. sanguinea!*). In this case the slaves commonly initiate the change of dwelling. At home the Polyergus appear to be under the guardianship of their slaves and to be treated like helpless dependents. They are sometimes even held back from their sorties by the auxiliaries.

The way in which the fertilized Polyergus queen starts her colony has not been observed. Forel and Wasmann have demonstrated that a friendly alliance may be easily effected in artificial nests between Polyergus queens and strange workers of *F. fusca*, and Wasmann concludes from this fact that new mixed colonies may be started by such consociations under natural conditions. But it does not appear to be necessary to accept this inference. The fertilized Polyergus queen may be quite as well able as other queen ants to raise unaided an incipient colony of small workers which could then pillage adjacent nests of *fusca* and provide themselves with the necessary auxiliaries. It has, moreover, been observed that Polyergus queens occasionally accompany the workers on their raids, and this habit may be still more pronounced in the queens of incipient colonies. I deem this probable because the young queens of other species very generally perform nearly all the functions which are later delegated more or less completely to the workers alone.

Tomognathus sublævis Mayr (Fig. 16). — This is a small, rather hairy ant, with broad and edentulous mandibles. It occurs only in northern Europe (Finland, Sweden, and Denmark). Two very careful studies of its habits have been published by Adlerz ('86 and '96). The auxiliaries are furnished by *Leptothorax acervorum* or *L. muscorum*, more rarely by *L. tuberum*. Adlerz's observations show that the Tomognathus secure these auxiliaries by attacking a Leptothorax colony, driving away the ants, and taking possession of the nest, together with the larvæ. The latter are then reared as helpmates. It is probable, however, that the Tomognathus may occasionally recruit the number of their slaves by making

sorties like Polyergus, for Adlerz succeeded in finding a nest of Tomognathus with two species of auxiliaries (*L. acervorum* and *muscorum*).

The mixed nests of Tomognathus-Leptothorax may contain males, queens, and workers of both the dominant and victimized species, a condition not known to occur in the case of other dulotic nests. The males of Tomognathus (Fig. 16, *a*) resemble the males of Leptothorax so closely that Adlerz failed

Fig. 16. — *Tomognathus sublævis* Mayr (after Adlerz); *a.*, male; *b.*, female (ergatoid).

to distinguish them till he published his second study ('96). The female is also of such a remarkable character that it, too, was originally overlooked. This sex is apterous (Fig. 16, *b*) and resembles the worker except in possessing ocelli and a receptaculum seminis.

The industrial instincts of Tomognathus are very rudimentary. It rarely or never excavates. It is able to feed itself if food is within reach, but it does not go in quest of provisions. This it leaves to the Leptothorax auxiliaries, by whom it is usually fed. Occasionally it may be seen caring for the larvæ. A number of Tomognathus which were isolated with larvæ and some food managed to live for 135 days, but the larvæ died or shriveled up. It seems probable, therefore, that Tomognathus depends on its slaves to a certain extent even for the care of its larvæ. When the colony is compelled to move to a new nest, the Tomognathus are usually deported by the Leptothorax; only rarely are the rôles reversed.

Sometimes when they desire to leave the nest, the Tomognathus are detained by the auxiliaries in much the same manner as Polyergus.

The males of Tomognathus do not mate with the females of the same nest, but do so readily with the virgin queens of other nests. The larvæ are so similar to those of the Leptothorax that Adlerz was unable to distinguish them. They are nourished with both liquid and solid food. Adlerz's description of the manner in which the larvæ are fed with pieces of flies tallies exactly with my observations on the primitive method of feeding adopted by the Ponerinæ and the Myrmicinæ of the genera Stenamma (Aphænogaster) and Pheidole ('00[a] and '00[b]).

Strongylognathus. — The species of Strongylognathus have perfectly edentulous, falcate mandibles, and more or less projecting postero-lateral corners to the head. Four species of the genus are known to occur in Europe: *S. huberi* Forel, *S. testaceus* Schenk, *S. christophi* Emery, and *S. cæciliæ* Forel. The habits only of the first two have been observed (Forel, '74 and '00[a]; Wasmann, '91), and these present interesting differences. Both species form mixed nests with *Tetramorium cæspitum*: *S. huberi* in southern Europe and northern Africa, and *S. testaceus* in southern and central Europe.

S. huberi seems like a diminutive and feeble caricature of Polyergus. Forel ('74) found by experiment that it would rob the larvæ and pupæ of Tetramorium and fight with the rightful owners after the manner of Polyergus. But it is not known whether *S. huberi* under natural conditions really provides its nests with auxiliaries by carrying on regular marauding expeditions. Forel, in a more recent paper on this species ('00[a], p. 275), expresses the opinion that it may not make sorties but keep up the mixed colony by alliance with the Tetramoriums instead. The workers of Strongylognathus are able to excavate, but they are fed by the Tetramorium workers. The latter are present in considerable numbers in the mixed nests, but up to the present time fertile queens of Tetramorium have not been found with them, though from what is known of *S. testaceus* one or more of these queens may perhaps be present in some cases.

S. testaceus is a commoner and better known form than *S. huberi*, and is supposed to represent a further advance towards a condition of social parasitism. The number of workers of *S. testaceus* is decidedly smaller in proportion to the number of Tetramoriums. On this account Forel maintains that the worker cast of *S. testaceus* is on the road to disappearing (*cf.* Anergates !). As fighters these workers, though provided with sabre-like mandibles, are indeed but sorry caricatures of Polyergus and decidedly less valiant than the workers of *S. huberi*. They do not kill the Tetramoriums, but seem to frighten them into deserting their larvæ and pupæ. Their weakness is further shown by the fact that they do not undertake their pillaging expeditions alone, but accompanied by their Tetramorium auxiliaries, and it is these latter that determine the success of the enterprise undertaken for the sake of robbing their own species. The workers of *S. testaceus* are even awkward in their attempts to carry away the conquered larvæ and pupæ. Although the Tetramorium auxiliaries commonly do all the work within the nest, such as excavating the galleries, caring for the larvæ and pupæ, and feeding the Strongylognathus, the latter are, nevertheless, able to feed themselves and to dig the nest, but they are apparently unable to care for the young.

Forel and Wasmann have succeeded in throwing considerable light on the obscure problem of the origin of the *S. testaceus*-Tetramorium colonies. The former found a single fertile queen of the Strongylognathus living amicably in the midst of a colony of *Leptothorax acervorum*; and Wasmann made the significant discovery of a fertile queen of the Strongylognathus and a fertile queen of Tetramorium living side by side in the same nest. This nest contained workers of both species (15,000–20,000 Tetramoriums and some thousands of Strongylognathus), and pupæ, about 70% of which were males and females of Strongylognathus. The remainder included two large male pupæ of Tetramorium. From this discovery Wasmann infers that the mixed nests of *S. testaceus*-Tetramorium are alliance colonies brought about by the adoption of fertilized queens of Strongylognathus by Tetramorium colonies.

The fact that these mixed nests rarely contain male Tetramoriums and never, so far as known, queen pupæ of this species, is explained by Forel ('00[a], p. 273) as the result of a general regulative instinct: "The females and males of Strongylognathus are smaller and less troublesome to nourish. This is obviously sufficient to induce the Tetramorium workers to rear them in the place of their own enormous queens and males, the larvæ of which they therefore undoubtedly devour or neglect, as they do in the case of all that seems to be superfluous."

After this brief review of the European species we may turn to our American dulotic ants.

16. **Formica sanguinea** Latr., subsp. **rubicunda** Emery.

Although the typical *F. sanguinea* is not known to occur in America, the species is, as Emery has shown ('93[a], p. 647), far more variable on this continent than it is in Europe. We should therefore be prepared to find a corresponding variability in its instincts, though this may not be commensurate with its taxonomic variation.

F. sanguinea is also occasionally found without slaves in America, but far more frequently it is attended by ants belonging to the great group of forms which centers about *F. fusca*. The best known subspecies of *F. sanguinea* in the Northern and Atlantic States is undoubtedly *rubicunda*. This is usually found with slaves belonging to *F. fusca*, var. *subsericea* Say, but one colony which I observed near Rockford, Ill., Sept. 16, 1900, contained about equal numbers of auxiliaries belonging to two species, *viz.*, *F. pallide-fulva* Latr., subsp. *nitidiventris* Emery, and *F. fusca*, var. *subænescens* Emery.

The above assumption that the habits of *F. sanguinea* in America may differ to some extent from those of the European form seems to be borne out by some recent observations of Forel ('00[c], pp. 11–12). Owing to Forel's long and very intimate acquaintance with the European *sanguinea*, these observations on our American form are of great value. He had occasion at Cromwell, Conn., to witness the attack of a very

small troop of *F. sanguinea* (probably *rubicunda*) on a large formicary of *F. subsericea*. "There were scarcely thirty *F. sanguinea*, and a third of these were recently hatched workers, still immature. The troop was evidently from an incipient colony. The *subsericea* had their nest about the roots of a great mullein (Verbascum). Their numbers were at least ten times as great as that of their assailants, and it may be admitted that each of them was fully as well armed and on the average larger and more robust than the *sanguinea*. Well, the mere arrival of the little troop of *sanguinea* sufficed to spread consternation through the nest of the *subsericea*, which betook themselves to flight with their larvæ and pupæ, but permitted the *sanguinea* to snatch these away and to conquer their nest without even making a serious show of defending themselves. Not more than one or two small *sanguinea* were killed in the fray. This fact is of importance, for in this instance we cannot allege the redoubtable weapons, hard integument, or even the impetuosity of the analogous attacks of the little troops of *Polyergus rufescens* which I have described in my 'Fourmis de la Suisse.' The bold and courageous tactics of the *sanguinea* were even less noticeable than in the European form of this species, which wages war on smaller and more feeble species than itself. I have never yet seen such complete and absurd cowardice as that of the American *subsericea*, a cowardice which brings clearly into prominence the instinctive adaptation to attack on the part of the enslaving, and to flight on the part of the enslaved species."

At Colebrook, Conn., during August, 1900, I had an opportunity to see a colony of *rubicunda* moving to a new nest. Each of the ants was carrying a motionless, curled-up *F. subsericea* in its jaws. The rather open phalanx of ants presented a very striking appearance as it moved from a shady hedge where the old nest was located, across a dusty road and disappeared in the undergrowth of a wood on the opposite side.

17. **Formica sanguinea** Latr., subsp. **rubicunda** Emery, var. **subintegra** Emery.

This variety, originally found by Mr. Pergande in the District of Columbia, has the same slave as the preceding, *viz.*, *F. subsericea*. During July, 1900, I found a very large nest of this variety on Naushon Island, Mass. It contained the usual auxiliaries and was compounded with a large nest of *Solenopsis molesta*.

18. **Formica sanguinea** Latr., subsp. **rubicunda** Emery, var. **subnuda** Emery.

This form was discovered by Mr. Dieck near Yale, D. C. Its auxiliaries are also furnished by *F. subsericea*.

19. **Formica sanguinea** Latr., subsp. **puberula** Emery.

This small form, which occurs in Colorado, is probably the one observed by McCook (**'82**, pp. 152–153). Its auxiliaries, according to this observer, belong to *F. schaufussi* and to a small black species (probably one of the western varieties of *F. fusca*).

20. **Formica sanguinea** Latr., subsp. **obtusopilosa** Emery.

Emery described this subspecies from New Mexico. Its auxiliary is not recorded, but is probably furnished by some variety of *F. fusca*, like *neorufibarbis* Emery or *neoclara* Emery.

21. **Polyergus rufescens** Latr., subsp. **lucidus** Mayr.

P. lucidus, the "shining slave-maker" of McCook, is the best known of the three American subspecies. It has been taken in several of the Atlantic States from Cape Cod to North Carolina and westward into Pennsylvania, but its exact geographical distribution has not yet been determined. Rev. P. J. Schmitt has sent me specimens from New Jersey, Maryland, and North Carolina. The specimens from the last-mentioned locality are decidedly opaque, thus resembling the European

form much more closely than do the typical specimens from other localities.

The habits of *P. lucidus* were first observed by McCook fully twenty years ago ('80). His account is fragmentary and barely sufficient to show that the habits are essentially like those of the European form. In the nest which he observed the slaves belonged to *F. pallide-fulva*, subsp. *schaufussi*. The same slaves were observed in a mixed nest taken on Cape Cod by Mrs. Mary Treat (Mayr, '86, p. 424). According to Pergande's observations cited by Wasmann ('94, p. 164), *F. pallide-fulva*, subsp. *nitidiventris*, is the auxiliary species in the District of Columbia. In the case observed by McCook it was, of course, the *F. schaufussi* which determined the character of the nest, since Polyergus does not excavate. Hence the title of McCook's paper is misleading. His observations on the feeding habits of *P. lucidus* are, as he remarks, "chiefly confirmatory of those recorded by Huber, Forel, and others in the European Polyergus." These, and a few additional notes on the belligerent disposition of this ant, are not, however, sufficient to leave no doubts in our minds that "our American species has precisely the same habit" of carrying on its dulotic expeditions, which he did not observe. Its slaves are certainly somewhat different in this country, and it is therefore to be presumed that the military tactics of the dulotic species may also be different.[1]

To McCook's inapposite criticism of Darwin's views concerning the phylogenetic origin of dulosis, I shall have occasion to return in the sequel.

22. **Polyergus rufescens** Latr., subsp. **breviceps** Emery.

This subspecies (Fig. 15, *a*, *b*), founded on specimens from South Dakota and Colorado, resembles the European *rufescens* still more closely than does *lucidus*, since it has the same sculpturing, opacity, and pilosity. It is, however, somewhat smaller, with a relatively shorter head, and its antennal scape is distinctly enlarged towards their tip. *P. breviceps* is evidently the form observed by McCook ('82, p. 384) in the

[1] *Cf.* the above-quoted observations of Forel on the American *F. sanguinea*.

Garden of the Gods. The slaves, according to McCook, belonged to *F. schaufussi*. Recently Rev. P. J. Schmitt has sent me specimens of *P. breviceps* from Breckenridge, Col. In this case the slaves accompanying the specimens belong to a rather small, monticolous subvariety of *F. subsericea* (Fig. 15, *c*, *a*).[1]

23. **Polyergus rufescens** Latr., subsp. **mexicanus** Forel.

This Mexican subspecies (Forel, '**99**, p. 129) is related to *breviceps*, but is larger, and without pubescence on the upper surface of the body. The exact locality of Forel's specimens is not given. It is safe to say that they must have been taken somewhere on the high plateau of central or northern Mexico. The auxiliary species is not recorded, but it is probable that the varieties of *F. fusca* (*F. subsericea* and *F. neorufibarbis*) recorded from the Mexican plateau (Forel, '**99**, p. 128) furnish the requisite slaves.[2]

24. **Tomognathus americanus** Emery.

This species (Fig. 17), which is both smaller and in other respects quite distinct from the European *sublævis*, appears to be very rare. The type specimens were taken by Mr. Pergande at Washington, D.C., in a nest of *Leptothorax curvispinosus* Mayr (Fig. 18), but no observations on the mutual relations of the two species were recorded. Rev. P. J. Schmitt of Beatty, Pa., writes me: "I have taken this species on but one occasion, — when I carried home a bushel of sifted vegetable matter from the woods. On examining this carefully

[1] While this article was going to press I discovered a fine large colony of *P. breviceps* in some woods near Rockford, Ill. The ants with their slaves — in this instance *Formica fusca* L., var. *subænescens* Emery — were living in a rotten stump in cavities excavated and long since abandoned by *Camponotus pennsylvanicus*. The Polyergus workers, like the Colorado specimens, are of small size with distinctly club-shaped antennal scapes. The head and thorax are opaque and the hairs on the abdomen are long and projecting. The abdomen is shining and nearly black in color.

[2] Buckley ('**66**, p. 170) describes a black female ant from Texas as *Polyergus texana*, but no one has since succeeded in recognizing this species. It is probably not a Polyergus at all.

I found about a dozen of the ants, which were readily recognized as Tomognathus. There may have been a few Leptothorax in the material,—certainly very few, if any,—but when

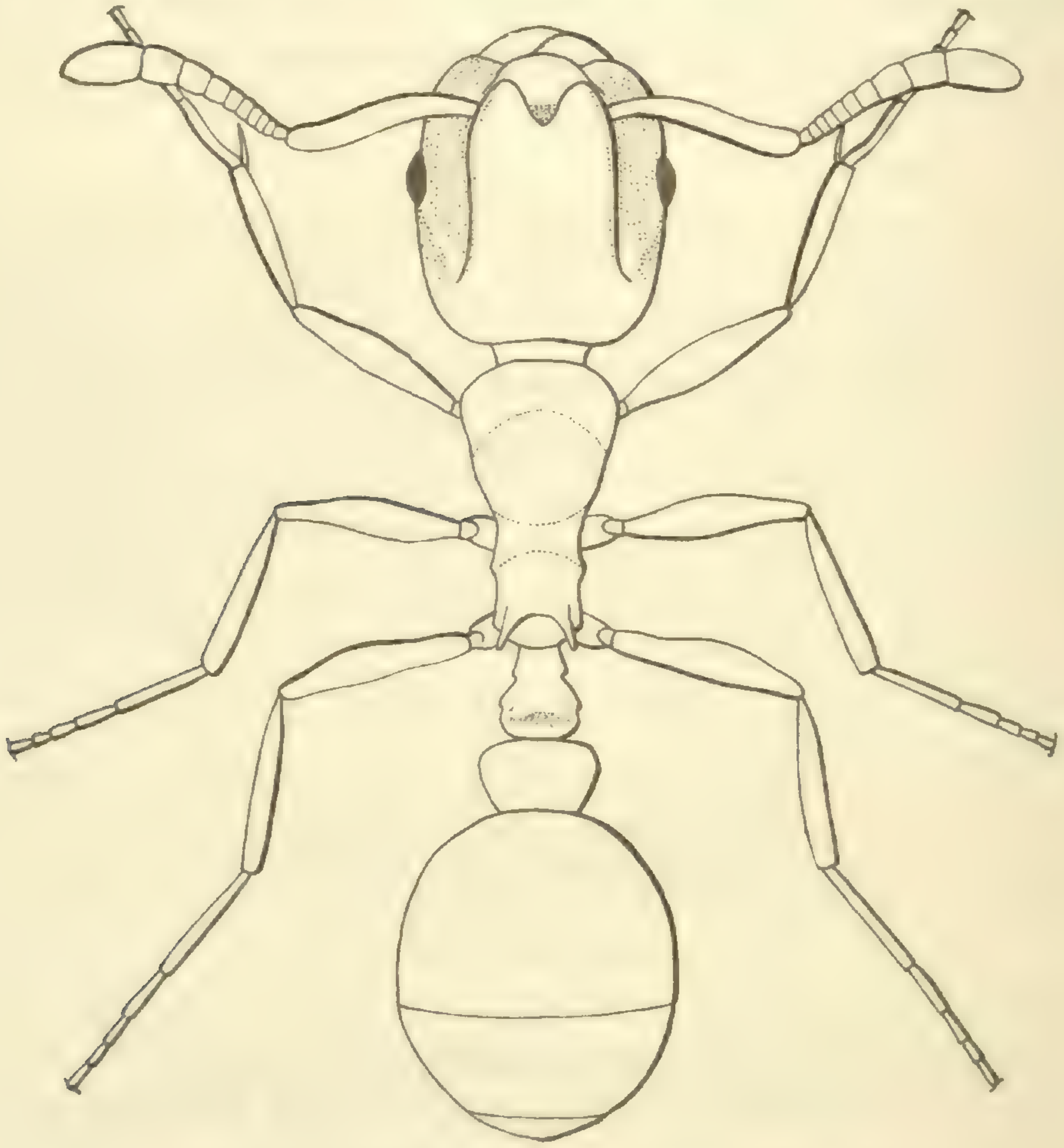

FIG. 17.—*Tomognathus americanus* Emery. Worker.

collecting with the sieve it is hazardous to affirm that any ants that are found belong to mixed or to independent colonies."

VI. COLACOBIOSIS.

It is very difficult to establish a clear distinction between the ants of this and the preceding category, since Strongylognathus is obviously transitional. Forel even includes this genus among the social parasites, while Wasmann includes the whole of Forel's category among the forms which I have designated as dulotic. I believe, however, that I am justified in erecting a special category for Anergates, which is the only well-known

social parasite, and for the American *Epœcus pergandei*, since these forms have become so extremely dependent on ants of other species that they have even lost the worker caste, thus leaving the species to be represented only by the fertile sexes like the vast majority of living organisms. The following condensed account of the work of European observers on *Anergates atratulus* is translated from Janet ('**97**, p. 58 *et seq.*), who incidentally adds to it some valuable observations of his own:

Anergates atratulus is a very bizarre ant, which inhabits central and northern Europe. It has been studied by Schenck ('**52**),

FIG. 18.—*Leptothorax curvispinosus* Mayr. Worker.

von Hagens ('**67**), Forel ('**74**), Adlerz ('**86**), and Wasmann ('**91**). As indicated by its name, it is a species which possesses no worker form. At the time of hatching from the pupa the

female presents very nearly the normal shape of queen ants and possesses wings. After fecundation, however, owing to an extraordinary development of the ovaries, her abdomen takes on the appearance of a sphere 4 mm. in diameter (Fig. 19, *b*), on which are seen in the form of little plates, isolated by the distention of the articular membranes, the strongly chitinized rings which constitute the whole external surface of the abdomen in the young individual (Fig. 19, *c*). The male (Fig. 19, *a*) is apterous, and its abdomen is strongly curved downwards. He has a dawdling gait. The strigil is well developed in the

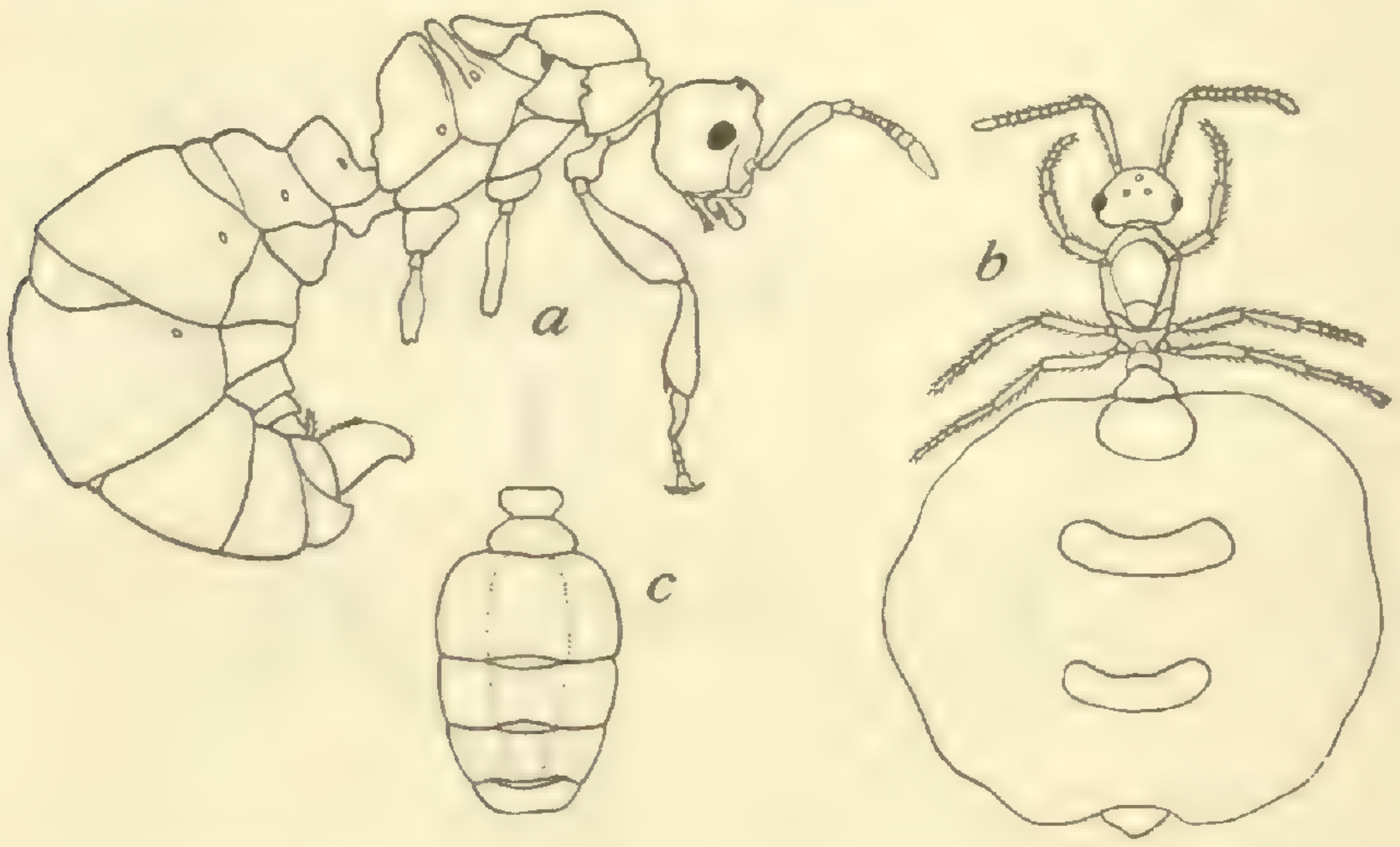

FIG. 19.—*Anergates atratulus* Schenck. *a*., male (after Adlerz): *b*., fertile female (after Forel); *c*., abdomen of virgin female (after Adlerz).

female, while in the male it is very small, but nevertheless pectiniform in certain specimens (Switzerland, Forel), although in others it lacks the teeth and is quite rudimental or even almost obsolete (Sweden, Adlerz; Holland, Wasmann; Beauvais, Janet).

In some young male specimens collected at Beauvais and preserved in alcohol, I observed by transmitted light, in the head, near the eyes, and of about the same size as these, the two mandibular glands and their excretory ducts opening at the base of the mandibles. These glands are therefore well developed, notwithstanding the fact that the mandibles, which are rounded at their tips, are much reduced. The male and female are both provided with well-developed ocelli. The antennæ are 11-jointed in both sexes.

Owing to the absence of wings in the males, mating takes place within the nests. This can be easily observed both in the natural and in the artificial nests. The couples may be killed without separating, by immersion in warm alcohol.

The nuptial flight of the females was observed by von Hagens ('67) on the 12th of August in the Rhine province. Some of the queens may perhaps fly to other nests and there be fertilized, and although there is usually only one fertile queen to a colony, it is possible that there may occasionally be several originating from different nests. If this were not the case we should have the condition to which Forel has called attention ('74, p. 343), *viz.*, that all mating must necessarily take place between brothers and sisters of the same colony.

The missing workers of *Anergates atratulus* are replaced in the mixed colonies by the workers of *Tetramorium cæspitum*. Whatever progeny is found in these colonies belongs exclusively to the Anergates. The Anergates of both sexes are nourished with food regurgitated from the mouths of their Tetramorium auxiliaries. They appear to be incapable of obtaining their food in any other manner.

Adlerz ('86, p. 231) and Wasmann ('91, p. 136) have ascertained that the Tetramorium auxiliaries of the Anergates pay relatively little attention to the young queens, while, on the other hand, they very frequently carry the males about and lick them long and assiduously. During this operation the males assume a characteristic motionless attitude. The two authors compare the attention thus bestowed on the male Anergates by the Tetramorium auxiliaries to that bestowed on myrmecophilous beetles that secrete certain substances of which the ants appear to be fond; *e.g.*, the attention bestowed on *Claviger testaceus* by *Lasius flavus*.

Adlerz and Wasmann have made experiments with a view to determining the method whereby a new mixed colony is formed, *i.e.*, by the association of the female Anergates with the Tetramorium workers. Adlerz ('86) in Sweden placed several unfertilized Anergates queens in a strange nest of Tetramorium. They moved about among the Tetramorium as if unperceived. He obtained nearly the same results on placing unfertilized

queens of Anergates in a normal colony of Tetramorium comprising a queen and her progeny. He also placed a considerable number of the larvæ, pupæ, and male and female imagines of Anergates in a normal colony of Tetramorium which were living in an artificial nest. In all cases the strangers were almost at once amicably received. Wasmann ('**91**, p. 142) obtained similar results in Holland. He observed that strange Tetramoriums did not in the least injure the male or female Anergates which he gave them, whereas they killed without mercy the *Strongylognathus testaceus* males or females that were placed in their nest. I have reported an experiment made on the same subject ('**96**, p. 27). I have also performed the following experiment: A normal colony of *Tetramorium cæspitum* provided with a deälated queen, and a normal colony of Anergates comprising an obese queen, some slender young queens, some males and some Tetramorium workers — both colonies comprising about the same number of individuals — were put together in an artificial nest. There ensued some struggles of relatively little importance, but some days later the obese queen was found lying dead in the midst of a cluster of Tetramoriums which seemed to be caring for her assiduously. Some weeks later all the Anergates males and females had disappeared, so that the colony again became a normal colony of Tetramorium. Von Hagens ('**67**) kept a single formicary of Anergates under observation during several consecutive years in the same place. It is difficult to assume that the number of Tetramoriums may be maintained in an Anergates colony by the introduction in one way or another of newcomers, so that I am inclined to believe with Wasmann ('**91**, p. 143) that the duration of such a colony is limited to the duration of the life of the Tetramoriums.

25. **Epœcus pergandei** Emery.

Emery ('**94**, p. 274) believes that this species, like Anergates, has no worker forms. Up to the present time it has been taken only once, when Mr. Pergande found it in a nest of *Monomorium minutum* Mayr, var. *minimum* Buckley, near Washington, D.C. This nest contained not only the winged

males and females of the parasitic species, but was also provided with the winged sexes of the Monomorium. When both species were put together in the same vial the Epœcus queens attacked and killed some of the males of Monomorium. These meagre data constitute all the forthcoming evidence for supposing that the habits of Epœcus are analogous to those of

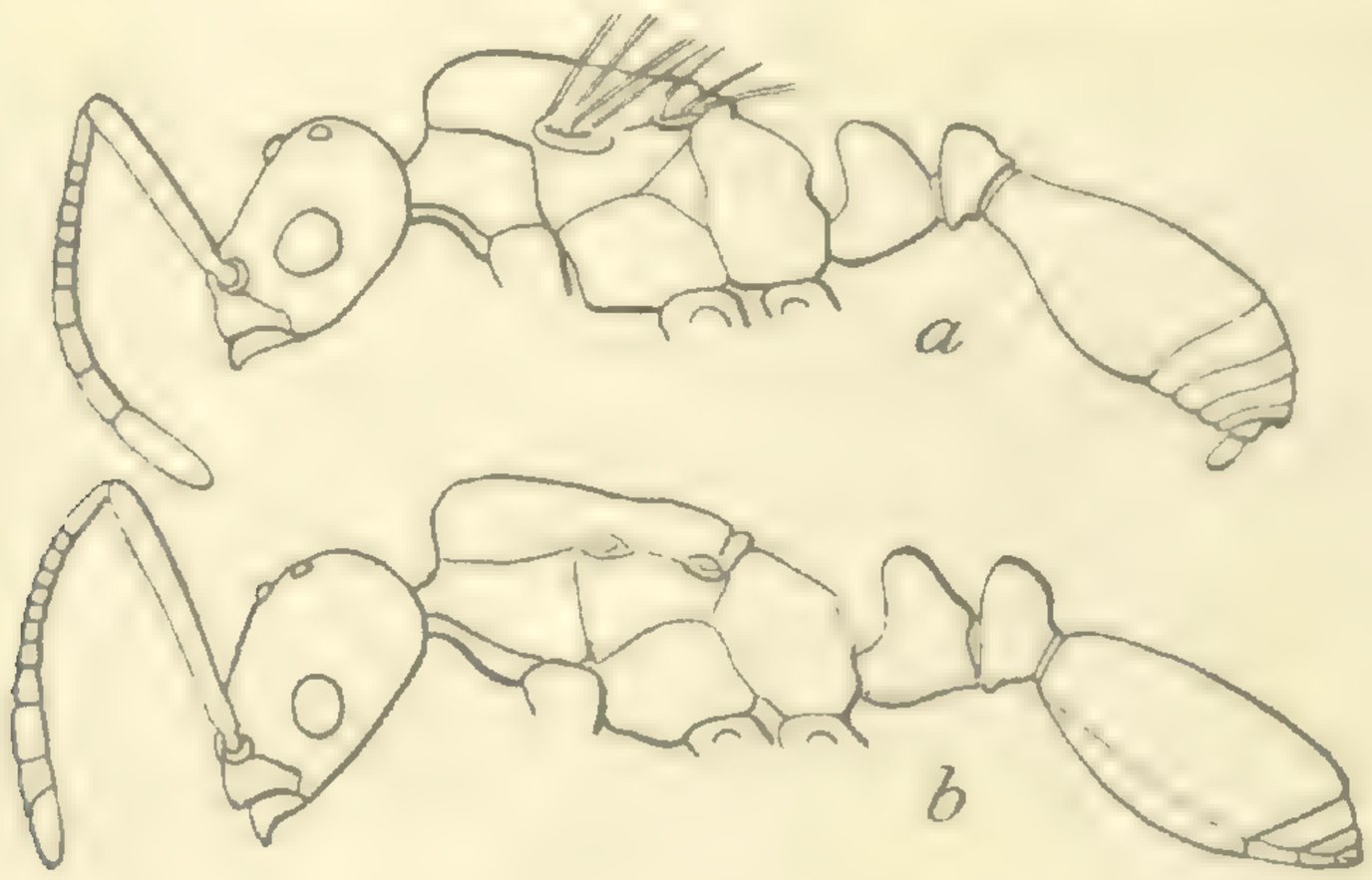

FIG. 20.—*Epœcus pergandei* Emery (after Emery). *a.*, male; *b.*, female.

the European Anergates. I may add that I have examined many dozens of *Monomorium minimum* nests in Texas in the hope of finding their rare parasite, but up to the present time my search has been in vain.

VII. SYNCLEROBIOSIS.

The mixed nests of uncertain origin and significance are of considerable interest, but unfortunately they are very rare, and as their origin has never been observed in any single instance either in Europe or America, it is possible to do little more in the present state of our knowledge than to catalogue the different cases. Mixed nests of this character are formed by the union of dominant species with unusual auxiliaries or *vice versa*, or by the close consociation of species which normally inhabit independent colonies. It is generally agreed that such nests must be either predatory unions, established after the manner of dulotic species by robbing the larvæ and pupæ of species which never function as normal auxiliaries, or by alliances between queens of different species before or soon after starting their colonies. Experiment may be expected to throw

considerable light on the extent to which such unions are possible. Forel ('**74**) and Wasmann ('**91**) have recorded a number of interesting observations, some of which are very similar to the following cases observed in America.

26. **Formica pergandei** Emery and **F. pallide-fulva** Latr.

Mr. Pergande (Emery, '**93**[a], p. 646) found near Washington, D.C., a mixed colony of *Formica pergandei* and the typical *F. pallide-fulva*, but the nature of the consociation was not determined. Emery suggests that the former species may be a true dulotic ant and *F. pallide-fulva* its auxiliary species. Mr. Pergande informed him that he had known of the existence of this colony for several years, but had seen only *pallide-fulva* in the nest till the summer of 1892, when the *F. pergandei* made their appearance in the colony. This observation would seem to favor an explanation by alliance rather than dulosis, or, at any rate, on the suppositon of dulosis the rôles of the two species would seem to be the reverse of that suggested by Emery, *pallide-fulva* being the dominant and *pergandei* the auxiliary species.

27. **Formica exsectoides** Forel and **F. subsericea** Say.

Forel ('**00**[c], p. 12) found a small mixed formicary of these species at Hartford, Conn. "There could be no doubt concerning the intimate life in common of the two species in the same nest. They entered and went out through the same doors, etc." Rev. P. J. Schmitt writes me that he has found at different times five different nests of *F. exsectoides-subsericea*. These invariably contained females of the *exsectoides* only. All these colonies were, moreover, obviously incipient, as shown by the fact that they contained scarcely more than fifty ants, including both species. These six cases observed by Forel and Schmitt are probably of the same nature as the very similar cases of *F. exsecta-fusca*, *F. truncicola-fusca*, *F. exsecta-pressilabris-fusca*, *F. pratensis-fusca*, and *F. sanguinea-rufa-fusca* described by Forel ('**74**) and Wasmann ('**91**). It is probable that the American *exsectoides*, like the European

exsecta, has dulotic proclivities which are shown only while the colony is young. In this connection the above-recorded fact, that weak colonies of *F. sanguinea* are found to have the most slaves, is perhaps significant.

28. **Dorymyrmex pyramicus** Roger, vars. **niger** Forel and **flavus** McCook.

A peculiar mixed colony containing both the common varieties of *Dorymyrmex pyramicus* was found by Forel at Faisons N. C. ('00c, p. 5). "There were two or three nests situated several meters apart. The yellow workers and the black workers entered and went out peaceably side by side, worked together and treated one another with every show of friendship. The two forms were, nevertheless, perfectly distinct, without presenting any transitional varieties. I completely demolished one of the nests and had the good fortune to find the females and males of *niger* and the male of *flavus*, the latter being larger and paler." Forel believes that this nest arose "without doubt by the fortuitous association of two fertile females, one of each variety." He therefore regards it as of the same nature as the peculiar mixed nest of *Tapinoma-Bothriomyrmex* which he described in the "Fourmis de la Suisse" ('74, p. 372).

29. **Pogonomyrmex barbatus** Smith and its var. **molifaciens** Buckley.

At Aguas Calientes, Mexico, Dec. 31, 1900, I happened on a huge gravel cone nest of the agricultural ant (*Pogonomyrmex barbatus*), containing about equal numbers of the typical species (with black head and thorax) and the entirely red var. *molifaciens*. There were no transitional varieties. Both forms were living together on the most amicable terms. As I entertained little hope of finding the queens, since this would, in all probability, have required a very careful excavation of the soil to a depth of from five to eight feet, I had to rest satisfied with digging into the nest a short distance and examining the hosts of belligerent workers that swarmed forth. As this was obviously an old and very flourishing colony, there can be little

doubt that it must have been formed by alliance between two or more queens representing the two distinct color varieties. The whole country about Aguas Calientes is covered with the most flourishing nests of these two forms, often very close to each other, so that it is not at all improbable that an occasional mixed nest should arise in this manner.

30. **Stenamma tennesseense** Mayr and **S. fulvum** Roger, subsp. **aquia** Buckley, var. **piceum** Emery.

Rev. P. J. Schmitt found this singular mixed nest near Beatty, Pa. The queen of the colony belonged to *S. tennesseense*. Rev. Mr. Schmitt was impressed by the fact that the nest was under a stone, whereas *tennesseense* normally occurs only in dead wood at Beatty. This seems to be generally true of the species. In Illinois and Wisconsin I have never taken it except in the old logs in the rather open forests.[1] It is a singular fact that in this and in nearly all the other cases of synclerobiosis the two consociating species or varieties represent a light and a dark colored form. This can scarcely be a mere coincidence, but I am unable to suggest any explanation of this peculiar phenomenon.

I cannot conclude this portion of my paper without expressing my indebtedness to Rev. P. J. Schmitt and to Professor Auguste Forel. These gentlemen have most generously sent me specimens of several of the rare and peculiar Formicidæ which I have figured.

(To be continued.)

[1] A somewhat similar mixed nest appears to have been found by Moggridge ('**73**, p. 37, footnote) at Mentone. This colony consisted of nearly equal parts of *Stenamma* [s. gen. *Messor*] *structor*, *barbara*, and the red-headed variety of *barbara*.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XVII. The Rotatoria.

H. S. JENNINGS.

The Rotatoria, or wheel animalcules, consist of minute, chiefly microscopic animals, which are everywhere abundant in fresh water. Along with the Protozoa they constitute by far the largest number of species and individuals among the animals to be found in pools, ponds, rivers, and lakes. A few are found in the ocean, but the rotifers are typically fresh-water organisms.

The most characteristic feature in the organization of the Rotatoria is the ciliated area at (or near) the anterior end of the body, serving as a locomotor organ or to bring food to the mouth. Coupled with the lack of cilia elsewhere on the body, this constitutes a character by which a rotifer may as a rule be recognized at once. This ciliated area is usually known as the corona. It varies excessively in form and structure, and in a few rare aberrant species is lacking.

Male and female differ in form, the males being, as a rule, much smaller than the females, and reduced in structure, — usually lacking the alimentary canal. The males are little known, many species existing in which they have never been observed. Discussions of the structure and classification of the rotifers are therefore based generally on the females alone.

The form of the body is exceedingly varied in the different representatives of the group, — ranging from spherical in Trochosphæra to the excessively attenuated form of *Rotifer neptunius* (Fig. 29) or the spiny, turtle-like form of Polychætus (Fig. 111). As a rule, however, the body is somewhat elongated, and is extended at the posterior end, behind the cloaca, to form a long stalk or a tail-like appendage, called the foot.

This frequently ends in two small points, called the toes. There may or may not be a distinct head, set off from the body by a neck. Dorsal and ventral surfaces are usually (not always) markedly differentiated. In many rotifers (Loricata) the cuticula or outer covering of the body is hardened to form a shell or *lorica;* this may bear elevations, spines, teeth, etc.

The simplest and probably primitive form of the corona is that of a plane disk covered with equal cilia, on the ventral side of the animal at the anterior end, as in Proales. From this the varied forms found have probably been derived, chiefly by the following steps : (1) the outer cilia became longer and stronger, forming a distinct marginal wreath; (2) the cilia within this wreath were partly or entirely lost; (3) a second wreath of cilia was developed (or has remained from the original cilia) within or without the above-mentioned wreath. Thus we obtain the condition, which has often been considered the primitive one, of two concentric wreaths, with the mouth between them. This condition is found only in much specialized forms.

In the alimentary canal can be distinguished a mouth, usually situated excentrically in the coronal disk and leading into a muscular pharynx, or *mastax*, which is furnished with chitinous jaws or *trophi;* a narrow œsophagus; a large stomach furnished with a pair of gastric glands, and an intestine leading to the anus. The latter is lacking in some groups. The jaws or trophi are very various in form and furnish a most important systematic character. Certain types of jaws are distinguished; of these, the more important are the malleate (Fig. 170) and the forcipate (Fig. 171). The other forms (ramate, Fig. 34; incudate, Fig. 54; uncinate, Fig. 10, etc.) may be related to one of these two types.

Points of especial practical importance for distinguishing species are the following : form, structure, and position of the corona; presence or absence, form and position, of the foot; form of the toes; presence, number, and position of the red eye-spots; structure of the jaws or trophi; presence or absence of the intestine and anus; nature of the cuticula, — whether soft and flexible or hardened to form a shell or lorica; presence

or absence of appendages on the body; and mode of life, — whether fixed or free-swimming.

The Rotatoria are a cosmopolitan group, so that the same species may be, and as a matter of fact frequently are, found in America, Europe, India, China, and Australia. Our rotifer fauna is, on the whole, so far as known, almost identical with that of the one other well-known continent, — Europe. From this it results that the only entirely satisfactory key for America or any other country would be one including all the species of the group. Two hundred and forty species have thus far been recorded from America; it is probable that nearly as many more will be found before the list can be considered to approach completeness. Under these circumstances the following key to known American species can be considered to have merely provisional value. Moreover, the species of many of the larger genera can be determined only from full descriptions and detailed figures; the key should in such cases be used in connection with fuller accounts.

The classification of the Rotatoria is in an unsatisfactory condition. The system employed by Hudson and Gosse in their monograph of the Rotifera is used almost exclusively, and is therefore adopted in essentials in the present key. But it is undoubtedly unsatisfactory in many ways, separating widely many closely related species, and bringing together some that are widely divergent in essential structure. A better classification has been outlined by Wesenberg-Lund, but this has not yet been worked out in sufficient detail to make its use practically satisfactory in such a key.

Owing to the large number of species of the Rotatoria and the frequent difficulty of assigning definite distinguishing characteristics even to the genera, it will be necessary for the key to the genera and species to be purely artificial in character. I give first, therefore, a systematic synopsis of the orders, suborders, and families. This synopsis is based on that given by Hudson and Gosse in the monograph of the Rotifera. I have introduced certain divisions not given by Hudson and Gosse, — such as the general division into Monogononta and Digononta; this division is one which is employed

by almost all later authors. Certain families, as the Apsilidæ, Plœsomadæ, Gastropodidæ, and Anapodidæ, are added to those given by Hudson and Gosse; this has become necessary through the progress of investigation since the monograph was written.

Many of the definitions are taken from Hudson and Gosse. The system is based throughout on the structure of the females.

SYNOPSIS OF THE ROTATORIA, WITH CHARACTERS OF THE CLASS, SUBCLASSES, AND ORDERS.

CLASS ROTATORIA OR ROTIFERA (WHEEL ANIMALCULES).

Small microscopic organisms, living chiefly in fresh water, bearing at the anterior end a ciliated area which takes various forms. Body often extended backward to form a stalk or foot. Pharynx with chitinous jaws; cloacal opening, when present, on the dorsal side, at the boundary between body and foot. Excretory organs in the form of fine tubes bearing "flame cells" or "vibratile tags," and opening into a contractile vacuole near the cloaca. Sexes separate; males usually minute, degenerate, lacking the alimentary canal.

SUBCLASS 1, DIGONONTA (HAVING TWO OVARIES).

Order 1. Bdelloida. Swimming with the ciliary wreath and creeping like a leech (or parasitic). Jaws ramate (Fig. 34).

Family 1. Philodinadæ.

Genera. Philodina, Rotifer, Callidina, Discopus.

Family 2. Adinetadæ.

Genus. Adineta.

Order 2. Seisonacea. Marine; parasitic on Nebalia; no corona. Males not degenerate.

Family 3. Seisonidæ.

Genera. Seison, Paraseison, Saccobdella.

SUBCLASS 2, MONOGONONTA (HAVING ONLY ONE OVARY).

Order 4. Rhizota. Fixed forms: foot ending in a disk or cup.

Family 4. Floscullariadæ.

Genera. Floscularia, Stephanoceros.

Family 5. Apsilidæ.

Genera. Apsilus, (Acyclus), (Atrochus).

Family 6. Melicertadæ.

Genera. Melicerta, Octotrocha, Limnias, Limnioides, Cephalosiphon. (Ecistes, Pseudœcistes, Lacinularia, Megalotrocha, Conochilus.

Order 5. Ploima. Not fixed; swimming with the ciliary wreath; not creeping like a leech. **Jaws never ramate.**

Suborder 1. Illoricata. Cuticula flexible, not hardened to form a shell or *lorica*.

Family 7. Microcodontidæ.

Genera. Microcodon, Microcodides.

Family 8. Asplanchnadæ.

Genera. Asplanchna, Asplanchnopus, Ascomorpha, (Hertwigia?).

Family 9. Synchætadæ.

Genera. Synchæta, (Anarthra), (Polyarthra).

Family 10. Triarthradæ.

Genera. Triarthra, Pedetes, Pteroessa, (Polyarthra and Anarthra).

Family 11. Hydatinadæ.

Genera. Hydatina, Rhinops, Notops, Triphylus, Cyrtonia.

Family 12. Notommatadæ.

Genera. Albertia, Taphrocampa, Pleurotrocha, Notommata, Copeus, Proales, Furcularia, Triophthalmus, Eosphora, Diglena, Distemma, Notostemma, Arthroglena, (Drilophaga) (Monommata?).

Suborder 2. Loricata. Cuticula stiffened to form a distinct armor or lorica.

Family 13. Rattulidæ.

Genera. Rattulus, Mastigocerca, Elosa. (Cœlopus?), (Diurella?). (Borthriocerca?).

Family 14. Dinocharidæ.

Genera. Dinocharis, Polychætus, Scaridium, (Stephanops).

Family 15. Salpinadæ.

Genera. Salpina, Diplax, Diaschiza, Diplois.

Family 16. Euchlanidæ.

Genera. Euchlanis, Dapidia.

Family 17. Cathypnadæ.

Genera. Cathypna, Distyla, Monostyla.

Family 18. Coluridæ.

Genera. Colurus, Metopidia, Monura, Mytilia, Cochleare, (Stephanops).

Family 19. Pterodinadæ.

Genera. Pterodina, Pompholyx.

Family 20. Brachionidæ.

Genera. Brachionus, Schizocerca, Noteus.

Family 21. Anuræadæ.

Genera. Anuræa, Notholca, Eretmia.

Family 22. Plœsomadæ.

Genus. Plœsoma.

Family 23. Gastropodidæ.

Genera. Gastropus, Hypopus.

Family 24. Anapodidæ.

Genera. Anapus, (Hertwigia).

Order 6. Scirtopoda. Swimming by means of branched appendages resembling in some respects those of the Crustacea. (The ordinal value of this character is decidedly doubtful.)

Family 25. Pedalionadæ.

Genera. Pedalion, Hexarthra.

Of uncertain sytematic position — Trochosphæra, Atrochus, Adactyla, Balatro, Cypridicola.

ARTIFICIAL KEY FOR THE DETERMINATION OF THE GENUS AND SPECIES OF AMERICAN ROTATORIA.

A1. Adult animals attached or united in colonies, usually dwelling in tubes; or if separate and free-swimming, then carrying the transparent tube with them. Foot ending in a flat disk or cup, which is attached to the substratum or to the bottom of the tube (or foot absent in Nos. 15–17) (free-swimming when young) Order RHIZOTA, H. & G.

B1. Not forming colonies; corona with long slender setæ and usually produced into a varying number of lobes bearing the setæ; mouth in the center of the large corona; cilia few, about the mouth, scarcely noticeable. Trophi uncinate (Fig. 10) . . Family FLOSCULARIADÆ

a1. Setæ not arranged in whorls or parallel rows on the lobes of the corona, but scattered or in groups . . . . . Floscularia

b1. Free-swimming, carrying the transparent tube

c1. Corona two-lobed; two eyes on the dorsal lobe . 1, *Floscularia mutabilis* Bolton

c2. Corona circular, ciliated, with five short prominences bearing setæ . . . . . 2, *F. pelagica* Rousselet (Fig. 1)

b2. Not free-swimming

c1. Corona without distinct lobes, but transversely truncate; setæ short, chiefly on the dorsal and ventral parts of the corona 3, *F. edentata* Collins (Fig. 2)

c2. Lobes of the corona three

d1. Lobes large, separated by deep curved depressions; setæ on the entire rim of the corona . . . . 4, *F. trilobata* Collins (Fig. 3)

d2. Lobes apparently but three — one large dorsal and two small ventral ones; but really with two minute additional lobes between the dorsal and ventral. See *c3*.

c3. Lobes five

d1. A long flexible process on the back of the dorsal lobe; lobes knobbed . . . . . 5, *F. cornuta* Dobie (Fig. 4)

d2. No dorsal process; lobes knobbed

e1. Lobes rather long and slender . . . . 6, *F. coronetta* Cubitt (Fig. 5)

e2 Lobes shorter and thicker . . 7, *F. ornata* Ehr. (Fig. 6)

d3. Lobes broad, not knobbed, all five well marked; setæ arising both from the summit of the lobes and from the intervening depressions . . . . . 8, *F. campanulata* Dobie (Fig. 7)

d4. The two lateral lobes very small, at first view hardly noticeable; dorsal lobe much larger than ventral

e1. Corona ornamented with dots arranged in symmetrical patterns; animal very small; tube sometimes lacking 9, *F. algicola* Hudson (Fig. 8)

e2. Larger, corona not ornamented as in *e1* 10, *F. ambigua* Hudson

d5. The five lobes forming long slender pointed arms, like those of Stephanoceros (Fig. 9) . . . . . 11, *F. millsii* Kellicott

c4. Lobes seven . . . . . 12, *F. regalis* Hudson

a2. Setæ arranged in whorls or oblique parallel rows on the five long pointed lobes of the corona . . . . 13, *Stephanoceros eichhornii* Ehr. (Figs. 9 and 10)

B2. Corona without setæ and apparently without cilia (a minute ciliary wreath can usually be detected on careful search)

a1. Corona with one dorsal lobe, the coronal cup edged with a delicate festooned membrane; body long, with a long slender tapering stalk, by which it is attached. Living in colonies of *Megalotrocha alboflavicans* . . . . . 14, *Acyclus inquietus* Leidy (Fig. 11)

a2. Coronal cup a large membranous sack; body short and thick; no foot, — the animal being attached by a flat disk . . . . Apsilus

b1. Coronal cup not oblique, its frontal margin horizontal 15, *A. vorax* Leidy

b2. Coronal cup and its frontal margin oblique; ganglion or brain in the neck

c1. Ventral margin of the coronal cup with a central convex lobe-like projection . . . . . 16, *A. bipera* Foulke (Fig. 12)

c2. Ventral margin of cup even, without central projecting lobe 17, *A. bucinedax* Forbes (Fig. 13)

B3. Corona without setæ and not produced into long lobes, but with strong conspicuous moving cilia forming a marginal continuous curve about the corona. In this curve there is a more or less conspicuous gap on the dorsal side. Mouth near the ventral side of the corona. On the body just below the corona either a single dorsal antenna, or two ventral ones, or all three, are noticeable. Trophi malleo-ramate (Fig. 16)

a1. Individuals attached, separate, or in branching non-spherical colonies of few specimens (1–30 or thereabouts)

b1. Corona of four lobes (or in No. 21 of three lobes): ventral antennæ obvious; dorsal antenna minute . . . . . Melicerta

c1. Lobes of the corona when expanded wider than the tube: a short, blunt chin on the ventral side below the corona: tube formed of nearly spherical pellets . . . . . 18, *M. ringens* Schrank (Figs. 14, 15, and 16)

c2. Lobes when expanded of the same width as the tube; chin long and pointed; tube of pellets having the form of a pointed cylinder . . . . . 19, *M. conifera* Hudson (Fig. 17)

c3. Lobes when expanded more than three times the width of the body; ventral antennæ very long; tube gelatinous, without pellets . . . . . 20, *M. tubicolaria* Ehr.

c4. Upper (ventral) pair of lobes separated by a large notch; lower (dorsal) pair almost confluent, so that the corona seems to have but three lobes; ventral antennæ short; chin two-pointed. Tube with ovoid fæcal pellets, or floccose, without pellets 21, *M. janus* Hudson (Fig. 18)

b2. Corona broad, of two lobes, with a wide dorsal gap; dorsal antenna minute; ventral antennæ obvious; tube without pellets Limnias

c1. Tube cylindrical, transparent, ringed by transverse ridges at regular intervals; five horny processes on the dorsal surface of the body, below the corona 22, *L. annulatus* Bailey (Fig. 19)

c2. Tube nearly cylindrical, not ringed, often partly covered with débris; no horny processes on dorsal surface of the body; ventral antennæ very short . . . . 23, *L. ceratophylli* Schrank

c3. Tube roughened with transverse rows of raised points; seven horny processes on the dorsal surface of the body below the corona; ventral antennæ nearly equal in length to the diameter of the tube . . . . . 24, *L. shiawasseensis* Kellicott

b3. Corona nearly circular, with a distinct dorsal gap; *dorsal antenna very large*, with two projections or hooks at its sides; ventral antennæ small or absent . . . . . Cephalosiphon

c1. Tube tapering to the foot, compact, strengthened with extraneous material; foot very long and slender . . 25, *C. limnias* Ehr. (Fig. 20)

c2. Tube irregular, semitransparent, gelatinous 26, *C. candidus* Hudson

b4. Corona a wide oval (or nearly circular), indistinctly two-lobed; dorsal gap minute, ventral antennæ obvious; dorsal antenna inconspicuous or absent . . . . . (Ecistes

c1. One or more dorsal hooks or projections below the corona; ventral antennæ minute; tube absent or small and irregular

d1. Two dorsal hooks below the corona; these sometimes branched into antler-like structures . . . 27, *O. melicerta* Ehr. (Fig. 21)

d2. A single dorsal hook below the corona; foot very long; animal without a tube, living in the mucilaginous matrix of the alga *Gloiotricha pisum* . . . . . 28, *O. mucicola* Kell.

c2. Antennæ (ventral) very short; no dorsal hooks

d1. Antennæ set wide apart; tube very irregular and variable, often beset with extraneous matter . . . 29, *O. crystallinus* Ehr. (Fig. 22)

d2. Dorsal gap of the corona very wide; tube opaque, regular, tapering slightly from top to bottom . . 30, *O. intermedius* Davis (Fig. 23)

c3. Antennæ long

d1. Antennæ very long and recurved, tube floccose; very small 31, *O. longicornis* Davis

d2. Corona large, nearly circular, crossed with thick ribs, tube loose, very irregular, clay colored . 32, *O. umbella* Hudson

a2. Not attached; inhabiting a tube; individuals separate or one adult grouped with its young

b1. Corona horseshoe-shaped; two antennæ on the ventral surface of the body, united almost to their tips 33. *Conochilus dossuarius* Hudson

a3. In clusters of many individuals, forming usually a spherical colony, appearing to the naked eye as a small yellowish or grayish ball

b1. Clusters attached

c1. Body (in known American species) with two or four opaque warts in a transverse row on the ventral side. No tube. Corona broad, kidney-shaped, with short axis dorso-ventral; antennæ inconspicuous . . . . . Megalotrocha

d1. Opaque warts two . . . . . 34, *M. semibullata* Hudson (Fig. 24)

d2. Opaque warts four . . . . . 35, *M. alboflavicans* Ehr. (Fig. 25)

c2. Dwelling in transparent gelatinous tubes; body without opaque warts or denticles; corona heart-shaped with long axis dorso-ventral; antennæ inconspicuous. 36, *Lacinularia socialis* Ehr.

b2. Free-swimming colonies or clusters . . . . . Conochilus

c1. Antennæ two, separate except at the base, situated on the corona, between the mouth and the ventral gap; colonies spherical, of many individuals . . . . 37, *C. volvox* Ehr. (Fig. 26)

c2. Antennæ united, so as to appear single, large and conspicuous, and situated on the corona: clusters usually unsymmetrical and containing comparatively few individuals . . 38, *C. unicornis* Rousselet (Fig. 27)

(*C. dossuarius*—see No. 33)

A2. Not fixed when adult: not forming colonies nor living in tubes (in a few rare cases the animal lives in a tube, but is never attached by its foot to the bottom of the tube, as in *A1*)

B1. Without *lorica*; *i.e.*, the cuticle of the animal is flexible, not stiffened to form an unyielding armor or *lorica*

a1. Swimming with the corona and creeping like a leech: body usually nearly cylindrical (dorsal and ventral surfaces not being conspicuously differentiated), and composed of rings which may be drawn one within the other in a telescopic fashion. Foot (reckoned from the cloaca to

the tip) usually ending in three toes, and bearing two to four spurs some distance from the tip. A dorsal proboscis behind the corona. Trophi or jaws ramate (Fig. 34). (Ovaries two.) Order BDELLOIDA

b1. Corona of two nearly circular retractile lobes, transversely placed Family PHILODINIDÆ

c1. Eyes two

d1. Eyes on the frontal column or proboscis . . . . Rotifer

e1. Constructing and dwelling in tubes 39, *R. mento* Anderson

e2. Not living in tubes

f1. Antenna very long (one-half to one-third as long as the body); foot short (one-third body length); spurs short and thick . . . . . 40, *R. macroceros* Gosse (Fig. 28)

f2. Antenna not remarkably long

g1. Body very long and slender, white and transparent; foot extraordinarily long (one and one-half times the length of the rest of the body); toes long and slender 41, *R. neptunius* Ehr. (Fig. 29)

g2. Foot not remarkably long

h1. Spurs not twice as long as the width of the joint to which they are attached. Body transparent or whitish, not colored or dark.

i1. Body whitish, opaque, passing gradually into the foot; spurs one and one-half times as long as the width of the joint to which they are attached, and forming an obtuse angle with each other 42, *R. vulgaris* Schrank (Fig. 30)

i2. Body thick, suddenly decreasing in size to form the foot, which makes up half the entire length of the animal; spurs produced to a longish point at the tip 43, *R. macrurus* Schrank

h2. Spurs at least twice as long as the width of the joint to which they are attached.

i1. Foot short, distinctly marked off; toes long, three-jointed; spurs thrice as long as the width of the joint to which they are attached, and with a constriction one-third of their length from the tip 44, *R. trisecatus* Weber (Fig. 31)

i2. Body slender; foot long, not distinctly marked off from the body; spurs twice as long as the width of the joint to which they are attached, slightly swollen at base 45, *R. elongatus* Weber (Fig. 32)

i3. Body colored — dark brown, usually covered with débris; transverse folds very marked; spurs almost, or quite, three times as long as the width of the joint to which they are attached 46, *R. tardus* Ehr. (Fig. 33)

d2. Eyes in the "neck" — directly over the brain, just above the jaws . . . . . Philodina

e1. Three teeth in each jaw (Fig. 34)

f1. Body beset with strong spines on the dorsal surface 47, *P. aculeata* Ehr. (Fig. 34)

f2. Body without spines, surface usually sticky, so that it is frequently covered with débris; spurs long and sharp, two and one-half times as long as the width of the joint to which they are attached . . . 48, *P. macrostyla* Ehr.

e2. Two teeth in each jaw

f1. Body smooth, colorless, very short, thickened in the middle; corona very large; foot sharply set off from the body; spurs shorter than the width of the joint to which they are attached . . . 49, *P. megalotrocha* (Fig. 35)

f2. Body colorless or reddish, not short and thick; foot not distinctly marked off . . . . . 50, *P. roseola* Ehr.

f3. Body greenish yellow, otherwise much like the last 51, *P. citrina* Ehr.

d3. Eyes none . . . . . Callidina

(The genus Callidina is a very large and difficult one; while the following species are all that have been identified in America, doubtless many more will be found.)

e1. Living in a tube . . . 52, *C. eremita* Bryce (Fig. 36)

e2. Not living in a tube

f1. Body with stout, blunt dorsal papillæ, especially on the segment next to the foot 53, *C. papillosa* Thompson (Fig. 37)

f2. Body without papillæ or spines

g1. Foot ending in toes

h1. Jaws (Fig. 38) small, with numerous (8–10) fine ridges ("teeth")

i1. Corona as wide as the neck; ridges ("teeth"), ten in each jaw (Fig. 38); spurs drawn to a slender point . . . . . 54, *C. elegans* Ehr. (Fig. 38)

i2. Corona not so wide as the neck: ridges or teeth, eight in each jaw (Fig. 39); spurs (Fig. 40) short and broad 55, *C. constricta* Dujardin (Figs. 39 and 40)

h2. Jaws with but two distinct teeth (in addition to a number of fine ridges)

i1. Teeth two in each jaw; spurs at least twice as long as the width of the joint to which they are attached, straight and thick; body colorless. Parasitic on Asellus 56, *C. socialis* Kellicott (Fig. 41)

i2. Each jaw (Fig. 42) with one large and two small teeth; spurs (Fig. 43) scarcely as long as the width of the joint to which they are attached, swollen at base; body yellowish
57, *C. musculosa* Milne (Figs. 42 and 43)

g2. Foot ending in a disk in place of toes; teeth, six to eight in each jaw; body reddish . 58, *C. magna* Plate

b2. Corona a flat surface covered with cilia, on the ventral side of the anterior end (Fig. 44) . . . . . Adineta

c1. Skin smooth; no eyes; proboscis without bristles and with a few cilia; body broad . . . . 59, *A. vaga* Davis (Fig. 44)

a2. Swimming with the corona; not creeping like a leech (sometimes creeping with the toes). Jaws of various forms, but never ramate.

A very large number of rotifers fall within this division, and the recognition of species, or in many cases even of genera, is very difficult. In order to reduce the difficulties to a minimum, I separate out a number of species having striking peculiarities, by means of the first five subdivisions given below (*b1–b5*). The following is to be especially noted; *only the species mentioned under a given characteristic possess that characteristic.* For example, any species having swimming appendages will be found under *b5*; species not named under this subdivision do not have such appendages.

b1. Spherical in form; no foot; ciliary wreath midway between the equator and one pole of the sphere
60, *Trochosphæra solstitialis* Thorpe

b2. Foot ending in a *single* pointed "toe"

c1. Corona a circle of strong cilia; mouth in the center; form of the body conical; one eye 61, *Microcodon clavus* Ehr. (Fig. 45)

c2. Corona an oblique ciliated disk, with two auricles; body brownish red or cherry red in color; one eye
62, *Notommata monopus* Jennings (Fig. 46)

c3. Corona an oblique ciliated surface with weak cilia; no eye; parasitic in fresh-water annelids . 63, *Albertia naidis* Bousfield

b3. Foot ending in two pointed projections, not side by side (as in most rotifers), but one dorsal, the other ventral. Otherwise much like No. 61
64, *Microcodides chlæna* Gosse (*orbiculodiscus* Thorpe)

b4. Corona extended dorsally into a large and broad proboscis, fringed with cilia and bearing near its end two red eyes
65, *Rhinops vitrea* Hudson (Fig. 47)

b5. Body bearing swimming or skipping appendages, in the form of movable spines, blades, or branching crustacean-like limbs: no foot

c1. Six branching appendages, somewhat like those of a crustacean; two small stylate appendages on the posterior dorsal surface. Eyes two . . 66, *Pedalion mirum* Hudson (Fig. 48)

c2. Twelve blade-shaped appendages, with serrate edges, arranged

in four groups of three each, at about the level of the jaws. One eye . . . . . 67, *Polyarthra platyptera* Ehr. (Fig. 49)

c3. Two very long spines (thrice the length of the body), attached ventro-laterally ; eyes two . . . . 68, *Pedetes saltator* Gosse

c4. Three very long spines, two lateral, one ventral. Two eyes 69, *Triarthra longiseta* Ehr. (Fig. 50)

(The remainder of the group (*a2*) are less easily recognizable. It will facilitate the use of the rest of the key to this subdivision to point out in a preliminary way certain striking characteristics of a number of species.)

No eyes. — *Hydatina senta* (No. 87), Albertia (No. 63), Pleurotrocha (No. 91), *Taphrocampa saundersiæ* (?) (No. 92), *Diglena contorta* (No. 93).

Eyes two. — Rhinops (No. 65), Diglena (Nos. 124–129), Distemma (No. 130), *Taphrocampa saundersiæ* (?) (No. 92), Triphylus (No. 85), Pedalion (No. 66), Pedetes (No. 68), Triarthra (No. 69).

Eyes three. — *Asplanchna priodonta* (No. 74), *Asplanchna herrickii* (No. 73), *Triophthalmus dorsualis* (No. 122), Eosphora (No. 123).

Parasitic. — External, — *Pleurotrocha parasitica* (No. 91). Internal, — Albertia (No. 63), Hertwigia (No. 80), *Proales wernecki* (No. 110).

Viviparous (the developing embryo frequently seen within the mother). — Asplanchnopus (No. 70), Asplanchna (Nos. 71–76), *Rhinops vitrea* (No. 65).

No foot. — Trochosphæra (No. 60), Pedalion (No. 66), Polyarthra (No. 67), Pedetes (No. 68), Triarthra (No. 69), Asplanchna (Nos. 71–76), Ascomorpha (Nos. 77–79), Hertwigia (No. 80), Anarthra (No. 81).

b6. No anus, the intestine ending blindly

c1. Foot present (viviparous) . . . . . Asplanchnopus

d1. Foot small, on the ventral surface 70, *A. myrmeleo* Ehr. (Fig. 51)

c2. No foot

d1. Large, clear, sac-like animals, with incudate jaws (Fig. 54); corona with two slight conical elevations. Viviparous Asplanchna

e1. Sac-like body with large projections or "humps"

f1. Four humps, — one dorsal, one ventral, and two lateral 71, *A. ebbesbornii* Hudson (Fig. 52)

f2. Three humps, — like the last but with the ventral one lacking (perhaps a variation of 71) . 72, *A. amphora* Hudson

e2. Sac-like body without humps

f1. Eyes three, — one large, on the brain, two small, lateral

g1. A bilobed glandular organ (Fig. 53, *a*) attached close to the opening of the ovary and excretory organs; 20–25 flame cells on each excretory tube
73, *A. herrickii* de Guerne (Fig. 53)

g2. No glandular organ as described in 73; flame cells but 3–5 on each excretory tube 74, *A. priodonta* Gosse

f2. Only one eye

g1. Jaws stout, with doubly pointed ends not serrated (Fig. 54); flame cells 10–20 on each side
75, *A. brightwellii* Gosse

g2. Jaws weaker, ending in a blunt tooth and a broad, thin plate (Fig. 55) (probably a variety of the last)
76, *A. girodi* de Guerne

d2. Very small rotifers, sac-like; corona rising slightly to a single apex; jaws not incudate; not viviparous
Ascomorpha

e1. A single large projecting process at the mid-dorsal edge of the corona

f1. Ovate in form; hyaline except the stomach; on each side of the body a "sub-dorsal groove". 77, *A. hyalina* Kellicott (Fig. 56)

f2. Flattened; in one view nearly circular, with a neck-like projection; in the edge view oblong, half as long as wide; skin stiffened so as almost to form a lorica
78, *A. orbicularis* Kellicott (?)

(This species is probably founded on dead specimens of *Gastropus stylifer*, No. 153.)

e2. No large projecting process on the corona; dorsal view sac-like; lateral view unsymmetrical, with a gibbous dorsal outline; color usually dark green . . . . 79, *A. ecaudis* Perty (*A. helvetica* Perty; *Sacculus viridis* Gosse) (Fig. 57)

b7. Foot not present; no appendages to body; anus present

c1. Parasitic in Volvox; having a large mid-dorsal projecting process on the corona . . . . 80, *Hertwigia parasita* Ehr.

c2. Not parasitic; body an elongated, parallel-sided, flattened sac; corona squarely transverse, with a single marginal wreath of cilia, and with two broad, flat setæ-bearing prominences on the dorsal side and two long styles near the ventral side . 81, *Anarthra aptera* Hood (Fig. 58)
(See also Trochosphæra, No. 60)

b8. Foot present, ending in two toes placed side by side; body without swimming appendages; anus present

c1. Form a broad, often swollen, cone, of which the foot forms the apex. Corona large, transverse, flat or strongly convex, with four

long styles and a number of styligerous prominences ; at the sides of the corona two large ciliated auricles, which may be retracted. A single eye . . . . . Synchæta

d1. The slender foot one-third to one-half the length of the remainder of the body ; toes minute . . . . 82, *S. stylata* Wierzejski (Fig. 59)

d2. Foot very short (less than one-sixth the length of the rest of the body)

e1. Body a swollen cone ; corona strongly convex, with two central thick, club-shaped prominences ; auricles very long, usually inclined backward . . . . 83, *S. pectinata* Ehr.

e2. Body a slender cone ; coronal surface almost flat, without club-shaped prominences ; auricles small . 84, *S. tremula* Ehr. (Fig. 60)

c2. Corona large, nearly transverse (slightly oblique), surrounded by a wreath of cilia which is interrupted ventrally, and bearing a number (3–7) of large prominences crowned with styles ; mouth near the ventral side of the corona

d1. Eyes two ; jaws forcipate ; foot slender, of three joints ; stomach with six long cæcal projections . . . 85, *Triphylus lacustris* Ehr. (Fig. 61)

d2. Eyes one or none

e1. Eye one ; body long conical, humped dorsally, its outline with three distinct curves ; corona with three styligerous prominences. Ciliary wreath encircling the corona and a sub-square space at right angles to the corona on the ventral surface . . . . . 86, *Cyrtonia tuba* Ehr. (Fig. 62)

e2. No eye ; body long conical ; a large rotifer, 87, *Hydatina senta* Ehr. (Fig. 63)

e3. Body large, sac-shaped, hyaline (like an Asplanchna), foot very small and retractile, situated at the posterior ventral angle of the body, almost on the ventral surface. Jaws malleate ; eye single . . 88, *Notops clavulatus* Ehr. (Fig. 64)

e4. Body strongly arched dorsally ; nearly flat ventrally ; cuticula thickened into a number of definite but inconspicuous folds or teeth (so that the animal might almost be considered loricate) ; foot continuing the body axis, but nearer the ventral side, with two small retractile toes ; one eye 89, *Notops pelagicus* Jennings (Fig. 65)

e5. Body almost square in ventral view ; foot one-third of total length, forming a continuation of the body axis ; one eye . . . . . 90, *Notops brachionus* Ehr.

c3. Corona without prominences bearing styles ; consisting of an oblique (or even ventral) disk or area covered with close-set cilia or with numerous interrupted ciliary curves. Two lateral evertible

ciliated projections (auricles) present in many species. Jaws forcipate. Soft, flexible, elongated rotifers ; exceedingly numerous
(Family NOTOMMATADÆ)

d1. Without eyes . . . . . Pleurotrocha

e1. Externally parasitic on fresh-water annelids
91, *P. parasitica* Jennings

e2. Free-swimming, body elongated, fusiform, with numerous marked annulations ; head enlarged, with a decurved hood or fleshy proboscis in front ; possibly one or two eyes present
92, *Taphrocampa saundersiæ* Gosse (Fig. 66)

e3. Free-swimming ; elongated, convex above and gibbous posteriorly, flat ventrally ; indications of a neck between head and body ; a small hook-like proboscis in front ; corona a ventral ciliated area one-third the length of the body ; foot very small ; toes minute ; auricles present ; two dorsal antennæ ; brain with dark granules at the posterior end
93, *P.* (Diglena) *contorta* Stokes

d2. One eye

e1. Eye in the neck, — that is, attached to the brain, some distance from the front of the head

f1. Body with numerous permanent conspicuous annulations or crenulations ; minute larva-like forms ; a small projection or "tail" just dorsad of the toes ; protrusible auricles present but frequently remaining hidden
Taphrocampa

g1. Body nearly cylindrical, short, thick ; brain opaque ; two auricles present

h1. Toes short and thick, conical, diverging so as to make an acute angle . . . . . 94, *T. annulosa* Gosse (Fig. 67)

h2. Toes longer, slender and curved ; so placed that the two together form the outline of a crescent
95, *T. selenura* Gosse (Fig. 68)

g2. Body elongated fusiform, crenulate ; head not enlarged ; brain containing a club-shaped granular region ; toes short ; stout, conical, forming an acute angle with each other . . . 96, *T. clavigera* Stokes
(See also No. 92, *T. saundersiæ*)

f2. Body without numerous permanent conspicuous annulations (though divisible into a number of joints)
(Cuticula somewhat stiffened and with a slight longitudinal dorsal cleft, — see Diaschiza, Nos. 181, 182)

g1. Very large species (.2 to .7 mm. in length), slow moving, usually enlarged behind the middle ; brain three (or five) lobed, clear or opaque ; corona extending onto

the ventral surface as a large movable ciliated "lip" (except in Nos. 99, 100, and 101); body projecting backward over the foot as a jointed or sac-like tail; auricles usually present . . . . . Copeus

h1. The two toes alike

i1. Tail slender, usually pointed, prominent, obscurely two-jointed; foot two-jointed

j1. Auricles very long (longer than the width of the head), extending laterally, ciliated only at the tip and along the anterior side . 97, *C. copeus* Ehr. (or *C. ehrenbergii* Gosse) (Fig. 69)

j2. Auricles very small or absent

98, *C. labiatus* Gosse

(97 and 98 are probably identical, 98 being founded on specimens of 97, with the auricles retracted)

i2. Tail thick, rounded, bag-like; auricles large, broadest at base

j1. Brain three-lobed . . . 99, *C. pachyurus* Gosse (Fig. 70)

j2. Brain five-lobed . . 100, *C. quinquelobatus* Stokes

(Probably a variation of 99)

i3. Tail small, inconspicuous; brain three-lobed

j1. Tail a minute tubercle; corona without lip; auricles very small; toes very small

101, *C. cerberus* Gosse (Fig. 71)

h2. The two toes dissimilar in form; tail slender, rounded; no lip 102, *C. americanus* Pell (Fig. 72)

g2. Moderate-sized or small (except No. 106); auricles present; toes small; brain usually partly opaque, not three-lobed; body often projecting behind, above the foot, as a large or small "tail" . . . . Notommata

(A difficult genus with very numerous species,—many of the American ones not yet identified)

h1. Tail long, almost or quite as long as the toes, so that the animal seems to end caudally in three prominent toes . . . 103, *N. tripus* Ehr. (Fig. 73)

h2. Tail inconspicuous or absent

i1. Brain clear; body fusiform; head narrower than the body; auricles small; toes minute cones; foot very short . 104, *N. brachyota* Ehr. (Fig. 74)

i2. Brain more or less opaque

j1. Color orange red or brick red, with a brownish tinge; body long, cylindrical, truncate at each end; cilia extending onto ventral surface almost

one-fourth the length of the body; toes very small; a separate foot scarcely distinguishable. Eye near the caudal end of the brain, almost completely hidden by the dense opacity of the latter . . 105, *N. truncata* Jennings (Fig. 75)

j2. Body subcylindrical or sac-like, swollen behind

k1. Very large and slow; body sac-like, with a swollen neck, between which and the body is a constriction; foot short; toes minute 106, *N. collaris* Ehr. (Fig. 76)

k2. Smaller; body subcylindrical; head wide; brain with a spherical opaque mass behind, bearing the eye, and connected by a tube with the front; foot very short, of two joints; toes small, long conical in form. Length, .2 to .3 mm . . . 107, *N. aurita* Ehr. (Fig. 77)

k3. Like *N. aurita*, but smaller and more slender; toes much longer and decurved; the eye sometimes hidden by the opaque brain. Length about .15 mm. . . 108, *N. cyrtopus* Gosse (Fig. 78)

j3. Body cylindrical, long, flexible, with a number of transverse constrictions and longitudinal folds, slightly tapering toward each end; auricles two stalked spheres, with the cilia confined to the spheres; toes very small; brain long, cylindrical, opaque at the caudal end; eye just in front of the opacity . . 109, *N. torulosa* Duj. (Fig. 79)

(*N. vorax* Stokes would be characterized in the same manner; it is probably a synonym of *N. torulosa*.)

(See also No. 62, *N. monopus* Jennings)

g3. No auricles, corona a ciliated surface, oblique or extending onto the ventral surface; brain clear; body cylindrical or larviform, usually small Proales

(A large, ill-defined genus, many of its American representatives unidentified or undescribed. The following American species have been reported)

h1. With a small decurved fleshy proboscis at the front

i1. Parasitic in Vaucheria, forming galls; body fusiform; toes small, straight, pointed 110, *P. werneckii* Ehr.

i2. Free-swimming; body cylindrical, slender, fluted longitudinally; proboscis large; eye very large; foot stout; toes slender; pointed . . . 111, *P. felis* Ehr. (Fig. 80)

h2. No proboscis

i1. Living in gelatinous masses of algæ, or sometimes free in waters full of unicellular algæ. Body nearly cylindrical or oval, slightly arched dorsally; eye large, in two parts, at the anterior border of the brain; foot and toes minute. Adults yellowish brown in color . . . 112, *P. algicola* Kellicott

i2. Body nearly cylindrical, thick, clumsy; head broad, truncate; foot very broad, with a depression in the median line; toes conical
113, *P. sordida* Gosse (Fig. 81)

i3. Body thick, broadest at the head, very flexible and changeable, colorless; toes minute, conical; eye small, inconspicuous . . 114, *P.* (Furcularia) *micropus* Gosse (Fig. 82)

i4. Body slender, soft, larva-like; toes minute; foot indistinguishable . . . . . 115, *P. decipiens* Ehr. (Fig. 83)

i5. Body strongly arched dorsally, flat or convex ventrally; foot conical; toes minute
116, *P. gibba* Ehr. (Fig. 84)
(The animal described under this name by Hudson and Gosse is totally different from Ehrenberg's)

e2. Eye frontal, placed near or at the anterior end of the body. Body nearly cylindrical, somewhat larviform, frequently enlarged in the lumbar region; anterior end conical; corona oblique; the two toes usually rather large and conspicuous
Furcularia

f1. Toes unequal, very long and slender
117. *F. longiseta* Ehr.

f2. Toes equal

g1. Toes blade-shaped, acute, decurved, the ventral edge of each notched with two (or sometimes three or more) teeth . . . . . 118, *F. forficula* Ehr. (Fig. 85)

g2. Toes round and stout at base, and abruptly passing at about a third of their length from the base into a hair-like filament . . . . . 119, *F. semisetifera* Glascott

g3. Body slender, compressed, the ventral line making a prominent angle; front rounded; face oblique; toes slender, straight, acute . . . . . 120, *F. gracilis* Ehr. (Fig. 86)

g4. Body oblong, slightly compressed, convex on the back, abruptly falling off steeply to the foot; toes stylate, straight, acute, nearly half the length of the body
121, *F. gibba* Ehr. (*Diaschiza semiaperta* Gosse?) (Fig. 87) (*F. micropus*, — see No. 114)

d3. Three eyes

e1. Eyes in a transverse row near the posterior end of the brain . . . 122, *Triophthalmus dorsualis* Ehr. (Fig. 88)

e2. One large eye on the brain ("cervical"); two smaller ones on the front . . . . . Eosphora

f1. Body sac-like, swollen behind, convex dorsally; head separated from the body by a neck, and bearing two prominent auricles; foot slender; toes short, acute

123, *E. aurita* Ehr. (Fig. 89)

d4. Eyes two

e1. Eyes frontal; body usually swelling behind and tapering toward the head; toes usually large; jaws prominent, forcipate . . . . . Diglena

f1. A decurved fleshy lobe or hook-like proboscis hanging onto the face from the dorsal margin of the anterior end

g1. Body massive, subcylindrical, dorsum convex, swollen behind; corona a ventral ciliated area; foot a single large joint; toes parallel-sided, abruptly pointed

124, *D. grandis* Gosse (Fig. 90)

g2. Body cylindrical, stout, obtuse at each end, not swollen behind; corona a long ventral area; toes long, curved, somewhat enlarged at base

125, *D. forcipata* Ehr. (Fig. 91)

g3. Eyes colorless; body slender at each end, swollen in the middle; proboscis acute; toes long, slender, curved strongly inward and downward . . 126, *D. circinator* Gosse (Fig. 92)

f2. No proboscis

g1. Body cylindric, long, slender; front broadly truncate (obliquely); foot short, thick; toes long, straight, slender

127, *D. caudata* Ehr. (Fig. 93)

g2. Body short, cylindric, abruptly truncate at each end: toes short, straight, acute, projected from the ventral side, nearly at right angles to the body axis

128, *D. catellina* Ehr. (Fig. 94)

g3. Body oblong, swollen posteriorly; head larger than neck; toes long, slender, straight, perfectly even in thickness, pointed; eyes very close together; jaws protrusile; alimentary canal large, always filled with green matter . . . . . 129. *D. biraphis* Gosse (Fig. 95)

e2. The two eyes cervical in position . . . . Distemma

f1. Body a slender cone; toes stout, recurved. toothed at base . . . . . 130, *D. forficula* Ehr.

B2. Cuticula stiffened to form an armor or lorica Suborder LORICATA

a1. Foot absent

b1. Lorica oval, compressed, without teeth or spines, formed of two **subequal convex plates ; one eye**

131, *Anapus ovalis* Bergendal (Fig. 96)

b2. Lorica truncate in front and behind, formed of a convex dorsal **and a concave ventral plate ; no teeth nor spines**

132, *Anuræa hypelasma* Gosse (Fig. 97)

b3. Lorica with six teeth or spines at the anterior edge (usually box-like in form, open at the anterior and posterior ends ; frequently **with spines at the posterior end also)**

c1. Lorica oblong, convex above, flattened beneath ; dorsal surface **marked off into polygonal areas**

d1. Lorica subconical in dorsal view, prolonged at the posterior end into a long, strong spine which is slightly narrowed at its base ; polygonal areas of the dorsal surface divided into right and left sets by a median longitudinal line

133, *Anuræa cochlearis* Gosse (Fig. 98)

d2. Lorica as in *d1*, but posterior spine lacking

Anuræa cochlearis, **var.** *tecta*

d3. Like *d1*, but there is a median dorsal row of polygonal areas **on the lorica** . . . . . *Anuræa cochlearis*, **var.** *stipitata*

d4. Lorica subquadrangular, with a spine at each of the two posterior lateral angles 134, *Anuræa aculeata* Ehr. (Fig. 99)

e1. As in *d4*, but the ridges separating the polygonal areas **strongly serrate** . . . *Anuræa aculeata*, **var.** *serrulata*

e2. As in *d4*, but the two posterior spines unequal

Anuræa aculeata, **var.** *valga*

c2. Dorsal surface of the lorica marked with longitudinal furrows **or striations** . . . . . **Notholca**

d1. Lorica a long, narrow, triangular pyramid, prolonged at the **posterior end into a long spine, equal in length to the body.** Anterior spines large, the right one of the two median spines immensely developed, so as to be as long as the body

135. *N. longispina* Kellicott (Fig. 100)

d2. Ovoid, truncated in front, the anterior spines rather short ; body rounded and without spines posteriorly ; longitudinal striations of dorsal plate strongly marked ; dorsal plate of lorica much wider than the ventral plate 136. *N. striata* Ehr.

d3. Much like *N. striata*, but with a subquadrangular projection **from the posterior orifice** . . . . . *N. striata*, **var.** *labis*

d4. Cylindro-conical in form ; dorsal plate extended posteriorly to form a tooth or spine ; ventral plate elevated posteriorly to **form a high angular projection** . . . 137, *N. foliacea* Ehr.

a2. **Foot present**

b1. Foot transversely wrinkled or ringed (as in Figs. 101–102) : very **retractile**

c1. Foot ending in a ciliated cup; lorica dorso-ventrally flattened, thin; corona transverse, ciliary wreath two lateral semicircles; eyes two . . . . . Pterodina

d1. Lorica very flat, circular, edges thin and without teeth or projections . . . . . 138, *P. patina* Ehr. (Fig. 101) (*P. valvata* is the young of 138)

d2. Lorica oval in dorsal view, concave on the dorsal side; edges of the lorica very thick; no teeth or other projections 139, *P. reflexa* Gosse (Fig. 102)

d3. Lorica thin, broadly ovoid or nearly circular, with a prominent tooth on each side at the posterior lateral margin 140, *P. bidentata* Ternetz

c2. Foot ending in two toes (usually small). Lorica arched dorsally, flat or slightly convex ventrally. Spines or teeth usually (not always) present at the anterior dorsal margin of the lorica (frequently elsewhere also) . . . . . Brachionus

d1. Lorica with *six* teeth or spines at the anterior margin of the dorsal plate (with or without posterior spines)

e1. The two middle anterior spines longest and curving outward; ventro-posterior part of lorica slightly prolonged to form a sort of sheath for the foot; on the dorsal side of this sheath a subsquare piece cut out, so that in dorsal view the foot orifice appears to be bounded by two or three teeth. Two posterior lateral spines long, short, or absent. (Excessively variable) . . 141, *B. bakeri* Ehr. (Fig. 103)

f1. Posterior spines short *B. bakeri*, var. *brevispinus* Ehr.

f2. Sheath for foot unsymmetrical (right side less developed); body covered with tubercles *B. bakeri*, var. *tuberculus* Turner

e2. Two middle anterior spines longest and curving outward: a square plate projecting from the middle of the posterior edge over the foot orifice. Usually two posterior lateral spines on the lorica, these disappearing with age 142, *B. variabilis* Hempel

e3. Anterior spines straight; a deep sinus between the two median ones. No posterior spines 143, *B. urceolaris* Ehr. (*f1.* Reddish, spines broader *B. rubens*, a variation of *B. urceolaris*)

d2. Lorica with but *four* teeth or spines at the anterior dorsal margin

e1. Median anterior spines very short; lateral ones very long. Toes large, each ending in two minute points, so that the foot at first view appears to be bifurcated

f1. Two posterior lateral spines on the lorica, the left one very small, the right one long 144, *B.* (or Schizocerca) *diversicornis* Daday

f2. The two posterior lateral spines equal
B. (or Schizocerca) *diversicornis*, var. *homoceros* Wierz

e2. Four variable (often subequal) anterior spines or teeth. Anterior ventral margin of lorica sinuous. Posterior part of the lorica rounded, either without teeth or with two or four teeth or spines. (Excessively variable) . 145, *B. pala* Ehr.

f1. Median anterior spines very long; no posterior spines
B. pala, var. *dorcas* Gosse

f2. Median anterior spines very long; two marked posterior spines . . . . . *B. pala*, var. *spinosus* Wierz.

c3. Four anterior spines of about equal length. Lorica subquadrate in dorsal view; thick, so that a transverse section would be nearly a circle. A slight invagination in the sides of the lorica in the lumbar region, causing blunt angles on the sides of the lorica. Entire surface covered with minute spinules. No posterior spines
146, *B. punctatus* Hempel (Fig. 104)

d3. Anterior margin of lorica without teeth or spines; at most merely sinuate

e1. Anterior dorsal margin sinuate, with a slight rounded notch in the middle. Lorica usually with irregular bluntly angled outlines and with faceted surface. Posterior extremity with two short blunt processes close to the foot
147, *B. angularis* Gosse

f1. The two posterior processes developed into spines
B. angularis, var. *bidens* Plate

e2. Anterior dorsal margin straight and truncated, with a small median sinus for the dorsal antenna; lorica thin, smooth, flexible. Dorsal surface highly arched; ventral, nearly flat. Toes pointed, and having the inner edges convex, the outer concave . . . 148, *B. mollis* Hempel (Fig. 105)

c3. Foot ending in two toes, and situated on the ventral side of the body; lorica an irregularly oblong or ellipsoidal box, marked with grooves and sometimes with vesicles, closed behind, opened ventrally for the protrusion of the foot . . . . . Plœsoma

d1. Lorica firm, with two wide grooves between three ridges passing transversely across the middle of the dorsal surface; a number of deep longitudinal grooves passing forward and backward from the ends of the transverse grooves; surface covered with fine areolations. Lorica in dorsal view about twice as long as wide, projecting at the anterior dorsal margin in a sharp median point, flanked by two small points or angles
149, *P. lenticulare* Herrick (Fig. 106)

d2. Body short, little longer than wide; lorica with grooves and ridges much as in the last, but more thin and flexible, and not

covered with areolations. Anterior dorsal margin of the lorica truncate, without points 150, *P. truncatum* Levander (Fig. 107)

d3. Lorica soft, covered with coarse areolations, partly arranged in very irregular rows; hinder part of the body retractile and extensile; when extended the body ends posteriorly in a blunt point . . . . . 151, *P. molle* Kellicott

d4. Lorica soft, covered with coarse irregular cuticular vesicles: body thick, short, rounded behind
152, *P. hudsoni* Imhof (Fig. 108)

c4. Foot projecting from the ventral surface, small, lightly ringed, and ending in a single pointed toe. Lorica compressed laterally, so as to be nearly circular in side view, with a sort of projecting collar for the protrusion of the head; in dorsal or ventral view oblong. Lorica rose color; internal organs blue, green, and orange . 153, *Gastropus stylifer* Imhof (Fig. 109)

c5. Foot very small and ending in two small toes; lorica thin, compressed laterally, flask-shaped, with the foot projecting from the ventral surface; size about .10 mm.
154, *Gastropus minor* Rousselet
(See also No. 223, *Cochleare turbo*)

b2. Foot present, not transversely wrinkled nor ringed (though often jointed)

c1. Foot distinctly jointed and ending in two small toes; lorica with an arched dorsal plate and a nearly flat ventral one; dorsal surface tuberculate or faceted but not bearing spines. Spines present at the anterior and posterior margins of the lorica

d1. Lorica with ten spines in front and four behind, its whole form markedly unsymmetrical; surface faceted and covered with raised points . . . . 155, *Brachionus militaris* Ehr.

d2. Lorica flattened, only slightly arched dorsally; dorsal surface faceted and roughened; two spines in front, turned ventrally at their tips; two posterior lateral spines. *No eye*
156, *Noteus quadricornis* Ehr. (Fig. 110)

c2. Lorica flattened and bearing one or more spines on its dorsal surface (spines at the posterior margin of the lorica may or may not be present also). Foot distinct, jointed, ending in one or two toes

d1. Spines on the dorsal surface of the lorica eight or twelve (including four at the posterior margin): lorica subquadrate, rough, toothed at the edges; head covered by a chitinous shield . . . . . Polychætus

e1. Eight spines on the dorsal surface of the lorica

f1. Foot bearing two large dorsal spines or spurs
157, *P. collinsii* Gosse

f2. Foot without dorsal spines . . 158, *P. serica* Thorpe

e2. Twelve spines on the dorsal surface of the lorica; foot with two long dorsal spines

159, *P. subquadratus* Perty (Fig. 111)

d2. Two spines on the dorsal surface of the lorica, a very long one rising from the middle, a short one from near the posterior margin. Head covered with a large semicircular shield

160, *Stephanops bifurcus* Bolton

d3. One spine from the middle of the dorsal surface of the lorica; otherwise much like the last

161, *Stephanops longispinatus* Tatem (Fig. 112)

d4. One long spine from in front of the middle of the dorsal surface of the lorica; also four curved spines from the posterior margin, and a short median point at the anterior dorsal margin

162, *Brachionus* (?) *gleasonii* Up de Graff (Fig. 113)

c3. A broad, nearly circular projecting plate over the head, appearing like a halo. Lorica cylindrical or pyriform, covering both dorsal and ventral surfaces; not faceted nor bearing spines on the surface (though there may be spines at the posterior edge). Foot distinct; toes two

d1. Lorica pyriform, with a narrow neck, slightly prolonged behind into three subparallel acute spines. Foot with a toe-like spine above the two toes

163, *Stephanops lamellaris* Ehr. (Fig. 114)

d2. Lorica cylindric, with a distinct neck; dorsal plate prolonged behind, over the foot, as a spoon-like shield

164, *Stephanops muticus* Ehr.

c4. The very short foot ending in one, two, or more very slender, stiff, bristle-like toes; where more than one are present, these may be equal or unequal. Lorica cylindrical, fusiform, ovate, or conical, closed all around but open at each end, smooth, rather thin; frequently showing a tendency to be spirally curved or otherwise unsymmetrical in form; often with one or two longitudinal ridges. Jaws unsymmetrical. One eye

Family RATTULIDÆ

(The Rattulidæ are so badly in need of revision that it is difficult to give a usable key to the species. Moreover, it is certain that many species in addition to those hitherto recorded will be found in America.)

d1. One long, straight, bristle-like toe (if others are present, these are much shorter than the largest one) . Mastigocerca

e1. Lorica with a single marked ridge, passing from the mid-dorsal line of the lorica forward and to the right. No teeth or spines at the anterior margin of the lorica. A single long toe, with three or more minute "substyles" at its base

f1. Body fusiform ; ridge high (one-fourth the diameter of the body) . . . . . 165, *M. carinata* Ehr. (Fig. 115)

f2. Body fusiform ; ridge low . . . 166, *M. rattus* Ehr.

f3. Body cylindrical, elongated (length about four or five times the greatest diameter), slightly enlarged in front. Ridge low, hardly noticeable. Toe about the length of the lorica . . . . . 167, *M. elongata* Gosse (Fig. 116)

e2. Lorica with two parallel longitudinal ridges close together, with a groove between them. No teeth at the anterior margin of the lorica

f1. The two ridges extending three-fourths the length of the body, which is fusiform in shape ; toe very long, straight 168, *M. bicristata* Gosse (Fig. 117)

f2. The two parallel ridges close together and extending only one-half the length of the lorica ; body shorter, ovoid, or oblong in side view . 169, *M. mucosa* Stokes (Fig. 118)

e3. Lorica without a ridge, cylindrical, ovate, or conical. (See also No. 167, *M. elongata*)

f1. One or more teeth or spines present at the anterior margin of the lorica

g1. Two unequal teeth or spines at the anterior margin of the lorica ; body long-fusiform 170, *M. bicornis* Ehr. (Fig. 119)

g2. Two sharp, slender, equal spines close together at the anterior margin of the lorica ; body a cone, largest in front and tapering to a toe about one-fourth the length of the body . 171, *M. birostris* Minkiewicz (Fig. 120)

g3. A single large median tooth projecting over the head from the anterior dorsal margin of the lorica. Body cylindrical, somewhat curved ; toe little more than half as long as the body 172, *M. capucina* Wierz. & Zach. (Fig. 121)

g4. A single short broad median tooth from the anterior dorsal edge of the lorica. Body ovate-fusiform, nearly symmetrical, constricted anteriorly to form a cylindrical neck. Toe not so long as the body 173, *M. multicrinis* Kellicott (Fig. 122)

f2. Anterior dorsal margin of lorica smooth, without teeth

g1. Body very broad, ovate, compressed dorso-ventrally, unsymmetrical ; toe four-fifths the length of the body 174, *M. lata* Jennings (Fig. 123)

g2. Body short and thick, arched dorsally, nearly flat ventrally ; lateral antennæ, at the posterior lateral parts of the lorica, protected by two prominent projecting spines ; toe longer than the body 175, *M. bicuspes* Pell. (Fig. 124)

d2. Two equal bristle-like toes; these not more than half the length of the body . . . . . Rattulus

e1. Lorica long-cylindrical, curved; anterior margin of the lorica with a single prominent tooth on the left side, and with a number of crenulations; toes very nearly half the length of the body, each with two substyles at the base

176, *R. tigris* Müller (Fig. 125)

e2. Body shorter, cylindrical, with two deep furrows encircling it just in front of the middle. Toes very short (less than half as long as the body is thick), and frequently retracted within the lorica, so as to be concealed

177, *R. sulcatus* Jennings (Fig. 126)

d3. Two unequal bristle-like toes, the shorter being more than half as long as the longer. (Additional short substyles may be present) . . . . . Cœlopus (or Diurella?)

e1. Body short and thick (about half as thick as long); curved, with a ridge on the right side; one or two short teeth at the anterior margin of the lorica; longest toe almost or quite half the length of the body, the other little shorter; four substyles in addition to the two toes

178, *C. porcellus* Gosse (Fig. 127)

e2. Like the last, but body only about one-fourth as thick as it is long . . . . . 179, *C. tenuior* Gosse

e3. No teeth at anterior margin of lorica; body curved, cylindrical or fusiform; no ridge; the two toes nearly equal, not quite so long as the body is thick

180, *C. brachyurus* Gosse (Fig. 128)

c5. Lorica cleft down the middle of the back by a fissure, whose sides are united by membrane; open at both ends for the projection of the head and foot. Toes blade-shaped

Family SALPINADÆ

d1. Lorica only slightly developed, covering only the dorsal half of the body; median fissure not strongly marked (resembling the species of Furcularia, Nos. 117–121). One eye Diaschiza

e1. Minute, swiftly moving; body short, cuneiform or cylindrical; head broad; lorica covering only the posterior third of the body; median fissure broad, inconspicuous

181, *D. lacinulata* O. F. M. (Fig. 129)

e2. Larger, body laterally compressed, arched dorsally; toes equal in length to the height of the body, curved toward the dorsal side . . . 182, *D. semiaperta* Gosse (Fig. 130)

d2. Lorica well developed, an oblong box enclosing the body, open at both ends and distinctly cleft down the middle of the back; furnished with spines or teeth at the anterior or posterior margins or both; one eye . . . . . Salpina

e1. Spines or teeth on the lorica as follows: two anterior dorsal, two anterior ventral, one (median) posterior dorsal, two posterior ventral. (Spines all rather short, tooth-like)
183, *S. mucronata* Ehr. (Fig. 131)

e2. Spines or teeth as follows: no anterior dorsals, two anterior ventral, one posterior dorsal, two posterior ventral. (The four following species are distinguished, all having the above characters; it is possible that they should be considered mere variations of a single species, *S. ventralis* Ehr.)

f1. Anterior ventral spines short and straight; posterior spines all short, the ventral ones recurved
184, *S. brevispina* Ehr.

f2. Anterior ventral spines very short, posterior dorsal spine short, decurved; posterior ventral pair longer than the posterior dorsal; lorica with a stippled collar
185, *S. ventralis* Ehr.

f3. Anterior ventral spines short, straight; posterior spines all long and straight, the ventral ones much the longer; lorica surface not stippled; dorsal cleft wide
186, *S. macracantha* Gosse

f4. Anterior ventral spines short, incurved; posterior dorsal conical, short, arched; posterior ventral long, stout, incurved; dorsal cleft narrow; lorica frequently stippled
187, *S. eustala* Gosse (Fig. 132)

e3. No posterior spines; anterior dorsal pair *very long;* anterior ventral pair also long and slender, but only about half as long as the dorsal ones. Lorica broad
188, *S. macrocera* Jennings (Fig. 133)

d3. Lorica as in *d2*, but without spines; the eye lacking Diplax

e1. Body triangular in section; lateral outline of lorica nearly ovate, but strongly arched dorsally and nearly flat ventrally
189, *D. trigona* Gosse

e2. Body much compressed, long and narrow in dorsal view, in side view nearly a parallelogram. 190, *D. compressa* Gosse

c6. Foot very long, of several joints; the two toes very long: lorica entire (not cleft dorsally nor ventrally), vase-shaped or compressed, not bearing spines. Head furnished with a chitinous covering. Eye one

d1. Lorica vase-shaped, faceted, and with surface roughened: head retractile within a chitinous cap; eye one; foot bearing two spines dorsally; foot and toes together nearly or quite twice the length of the body . . . . . Dinocharis

e1. A short spine dorsally between the two toes
191, *D. pocillum* Ehr. (Fig. 134)

e2. No spine between the two toes . 192, *D. tetractis* Ehr.

d2. Lorica somewhat vase-shaped, thin, smooth, and transparent; head with a thin chitinous covering; eye very close to or upon the mastax . . . . . Scaridium

e1. Body nearly cylindrical or slightly compressed laterally; body, foot, and toes of about equal length

193, *S. longicaudatum* Ehr. (Fig. 135)

e2. Body broad, ovate or pear-shaped; toes about as long as body and foot together 194, *S. eudactylotum* Gosse (Fig. 136)

c7. Lorica of two dissimilar plates, one dorsal and one ventral, the former usually larger and arched (except in No. 201), the latter flat or slightly convex. Large transparent rotifers, with a single eye. Foot jointed, the two toes large, usually blade-shaped

Euchlanis

d1. Lorica oval or ovate, gently arched above, nearly flat below; transverse section a low segment of a circle

e1. Ventral plate with a flange projecting laterally from its junction with the body; anterior dorsal edge with a broad gap having a straight bottom (Fig. 138); hind dorsal edge notched . . . . . 195, *E. dilatata* Ehr. (Fig. 137)

e2. Ventral plate without a lateral flange; anterior dorsal margin with a small subsquare notch 196, *E. deflexa* Gosse

d2. Lorica a long, narrow oval or an ellipse, depressed; anterior dorsal edge membranous; transverse section a low circular segment; ventral plate elliptical and broadest at the hind end

197, *E. lyra* Hudson

d3. Lorica broadly oval or ovoid, constricted near the middle, the dorsal plate much wider than the ventral and turned downward and inward . 198, *E. pyriformis* Gosse (Fig. 139)

d4. Lorica roof-shaped, with sloping sides; not rising to a ridge; cleft for a short distance behind. Ventral plate flat, smaller in outline than the dorsal. A small species, 199, *E. oropha* Gosse

d5. Lorica with a high median dorsal keel; lateral edges of the lorica extending laterally into two wide shelves, so that the animal seems to have three keels, and is triangular in section. Outline from above ovoid . . . . 200, *E. triquetra* Ehr.

d6. Dorsal plate carinate; lorica ovate, flask-shaped; foot four-jointed; toes more than half the length of the lorica

201, *E. ampuliformis* Herrick (*E. propatula*) Gosse (?) (Fig. 140)

c8. Lorica of two plates, the ventral one nearly flat, the dorsal one slightly or considerably elevated. The two plates separated by a deep lateral furrow covered with flexible membrane. Body ending posteriorly in either one or two large rod-shaped toes (the foot proper being short and inconspicuous). One eye

Family CATHYPNADÆ

d1. Toes two

e1. Lorica subcircular or broadly ovoid, with a wide and deep lateral furrow . . . . . Cathypna

f1. Lorica rather flattened, dorsal and ventral plates nearly equal in size, broadly oval in outline ; toes two-fifths as long as the lorica, each with a distinct angle or shoulder at the side, near the tip, and with a small sharp claw, which continues the inner side of the toe 202, *C. luna* Ehr. (Fig. 141)

f2. Lorica ovoid, the dorsal plate ending behind in a subsquare plate with its posterior lateral corners extended into distinct angles. Toes rod-shaped, very long (almost as long as the lorica) . . 203, *C. leontina* Turner (Fig. 142)

f3. Very large (.31 mm. in length) ; lorica long ovoid or truncate elliptical in form ; dorsal plate projecting posteriorly as a semicircular plate over the foot. Toes about half the length of the lorica . . 204, *C. ungulata* Gosse

e2. Lorica longer, usually a long ellipse, open in front ; lateral furrow not pronounced . . . . . Distyla

f1. Dorsal plate faceted, *i.e.*, marked off into polygonal areas

g1. Dorsal plate ending behind in a quadrangular projection with nearly parallel sides

205, *D. ohioensis* Herrick (Fig. 143)

g2. Dorsal plate ending behind in two sharp points separated by a broad gap . 206, *D. stokesii* Pell (Fig. 144)

g3. Dorsal plate ending behind in a single sharp point

207, *D. ludwigii* Eckstein (Fig. 145)

g4. Dorsal plate not ending behind in projections. but bearing in the posterior lateral region two short projecting teeth, protecting two lateral antennæ. Foot conspicuous, three-jointed 208, *D. spinifera* Western (Fig. 146)

f2. Dorsal and ventral plates marked with small crescentic elevations arranged in somewhat regular patterns. Lorica of truncate elliptical form, without posterior projections

209, *D. signifera* Jennings (Fig. 147)

f3. Lorica flexible, smooth, or marked with irregular wrinkles or longitudinal folds

g1. Small, lorica parallel-sided, soft, with irregular wrinkles and longitudinal folds . . 210, *D. flexilis* Gosse

g2. Lorica long, flexible, nearly parallel-sided when extended (Fig. 148) ; when completely retracted broader in front and ending in two strong incurved points (Fig. 149). Dorsal surface with a few irregular longitudinal folds . 211, *D. gissensis* Eckstein (Figs. 148 and 149)

g3. Lorica soft, much broader behind and tapering forward to the narrow head when extended; broad ovate, truncate, when retracted. Toes short, with claw about one-third the length of the toe . 212, *D. inermis* Gosse

d2. One rod-shaped toe . . . . . Monostyla

e1. Lorica broad ovate, flat, projecting anteriorly into two long sharp, outwardly curved spines, separated by a narrow rounded notch . . . . . 213, *M. quadridentata* Ehr. (Fig. 150)

e2. Lorica ovate, toe broadly fusiform

214, *M. closterocerca* Schmarda (Fig. 151)

e3. Lorica without spines; toe rod-shaped or tapering to the tip

f1. Lorica broadly ovate, with a crescentic concavity in front when the head is retracted. Toe with parallel sides

215, *M. lunaris* Ehr. (Fig. 152)

f2. Lorica ovate, without a crescentic concavity in front when the head is retracted, but nearly truncate. Toe short, rod-like . . . . 216, *M. cornuta* Ehr. (Fig. 153)

f3. Dorsal plate high arched, ventral somewhat convex; anterior dorsal edge of lorica with a shallow, rounded or quadrate notch; ventral plate with a much deeper, broader notch . . . . . 217, *M. bulla* Gosse (Fig. 154)

f4. Lorica ovate; two anterior lateral points when the head is retracted. Ventral plate flexible, with irregular longitudinal folds . . . . 218, *M. arcuata* Bryce (Fig. 155)

f5. Lorica subcircular, but little longer than broad; two inwardly curved sharp points at the anterior edge when the head is retracted; toe rod-like, ending in two short claws projecting from between two minute spines

219, *M. robusta* Stokes (Fig. 156)

f6. Lorica subovate, with a straight anterior margin when contracted (insufficiently described)

220, *M. truncata* Turner

f7. Lorica broadly ovate, truncate, rounded dorsally. Dorsal plate strengthened by two diverging longitudinal ribs about equidistant from each other and from the lateral edges of the plate, rendering the anterior margin slightly angulate where they join it . . . 221, *M. ovata* Forbes

e4. Lorica a soft, flexible, corrugated skin, hardly deserving the name of lorica. Body oblong, subcylindric. Toe rod-shaped, with a short claw . . . . 222, *M. mollis* Gosse

c9. Lorica of a single piece, like a coat, covering only the anterior half of the dorsal surface of the body, or less; foot long, jointed, with two minute toes . . . . . Cochleare

d1. Lorica three-sided . . . 223, *C. turbo* Gosse (Fig. 157)

c10. Head surmounted by an arched chitinous shield, appearing in side view like a hook; lorica either arched, and compressed laterally, or dorso-ventrally flattened

d1. Lorica arched, somewhat compressed laterally, so as to be higher than wide; open behind and in front, and sometimes open on the ventral side. Minute, inconspicuous rotifers Colurus

e1. Lorica ovate as viewed from above; produced caudally (as seen in dorsal view) into two acute spines, separated by a deep sinus; ventral surface of lorica cleft
224, *C. deflexus* Ehr. (Fig. 158)

e2. Lorica not cleft ventrally; excavate behind, so as to form two teeth with a shallow notch between them
225, *C. bicuspidatus* Ehr. (Fig. 159)

e3. Pear-shaped, widest behind, in dorsal view; ventral surface cleft; caudal notch very shallow, between two short terminal points; foot and toes three-fourths the length of the lorica . . . . . 226, *C. caudatus* Ehr.

e4. Ovate in dorsal or lateral view, the posterior end rounded, without points; lorica cleft ventrally. Foot very small
227, *C. obtusus* Gosse (Fig. 160)

e5. Elongate-ovate in dorsal view; caudal margin rounded, without cleft or points; ventral cleft interrupted in front of the middle, so that the openings for the head and foot are not continuous . . . . 228, *C. agilis* Stokes (Fig. 161)

e6. Lorica ovate in dorsal view, high behind, low in front; a long, stiff, pointed, hyaline crest extending backward and upward from the middle of the anterior dorsal edge of the lorica . . . . . 229, *C. cristatus* Rousselet (Fig. 162)

d2. Height and width of lorica about the same; lorica forming an ovate box with surface marked into areas; a thin ridge on the mid-dorsal line; a similar ridge on the mid-ventral line from the anterior margin to about the middle of the length
230, *Metopidia salpina* Ehr. (Fig. 163)

d3. Lorica flattened, wider than high, usually turtle-like in appearance; open only in front and behind, not along the ventral middle line . . . . . Metopidia

e1. Outline of lorica varying from elliptical through oval and ovate to orbicular, but without teeth, spines, or prominent angles (except at the sides of the foot and head, where angles are necessarily formed, owing to the openings in the lorica)

f1. Lorica nearly circular, much depressed; dorsal plate with a very low rounded median ridge and with a submarginal line of corrugation . . . . 231, *M. solidus* Gosse

f2. Lorica oval or ovate, much depressed, evenly rounded

above ; ventral plate excavate behind for the foot ; eyes two . . . . . 232, *M. lepadella* Ehr. (Fig. 164)

f3. Similar to the last, but with four eyes. (Perhaps only a variation of the last) . . . . . 233, *M. bractea* Ehr.

f4. Lorica elliptical or ovately oblong ; toes long, slender ; eyes two or four ; foot of three nearly equal joints 234, *M. oblonga* Ehr. (Fig. 165)

f5. Like the last (of which it is probably only a variation), but with the third joint of the foot equal in length to the other two together ; the two toes protruded between two minute lateral spines . 235, *M. dentata* Turner (Fig. 166)

f6. As in *M. oblonga*, but with the anterior margin of the lorica covered with points, so as to form a stippled collar ; the angles of the lorica at the sides of the head very sharp, so as almost to form spines (variation of *M. oblonga ?*) 236, *M. collaris* Stokes (Fig. 167)

e2. Lorica rhomboid-ovate in outline ; dorsal plate roof-shaped, lower behind and ending in an obtuse point ; ventral surface flat . . . . . 237, *M. rhomboides* Gosse

e3. Lorica ovate, ending behind in an acute point 238, *M. acuminata* Ehr.

e4. Lorica with three wide, thin wings, one dorsal and two lateral ; the dorsal view nearly circular 239, *M. triptera* Ehr.

e5. Lorica broad behind, having four prominent angles, two lateral and two posterior 240, *M. ehrenbergii* Perty (Fig. 168)

e6. Lorica with two great spines at the anterior dorsal margin ; these separated by a narrow median notch 241, *M. cornuta* Schmarda (Fig. 169)

Ann Arbor, Mich., Feb. 5, 1901.

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LIST OF FIGURES—PLATE I.

1. Floscularia pelagica, after Rousselet.
2. " edentata, after Weber.
3. " trilobata, after Hudson and Gosse.
4. " cornuta, after Weber.
5. " coronetta, after Weber.
6. " ornata, after Weber.
7. " campanulata, after Weber.
8. " algicola, after Hudson and Gosse.
9. Stephanoceros eichhornii, after Weber.
10. " " , jaws, after Hudson and Gosse.
11. Acyclus inquietus, after Leidy, from Hudson and Gosse.
12. Apsilus bipera, ventral view of head, after Foulke, from Stokes.
13. " bucinedax, after Stokes.
14. Melicerta ringens, in tube, after Hudson and Gosse.

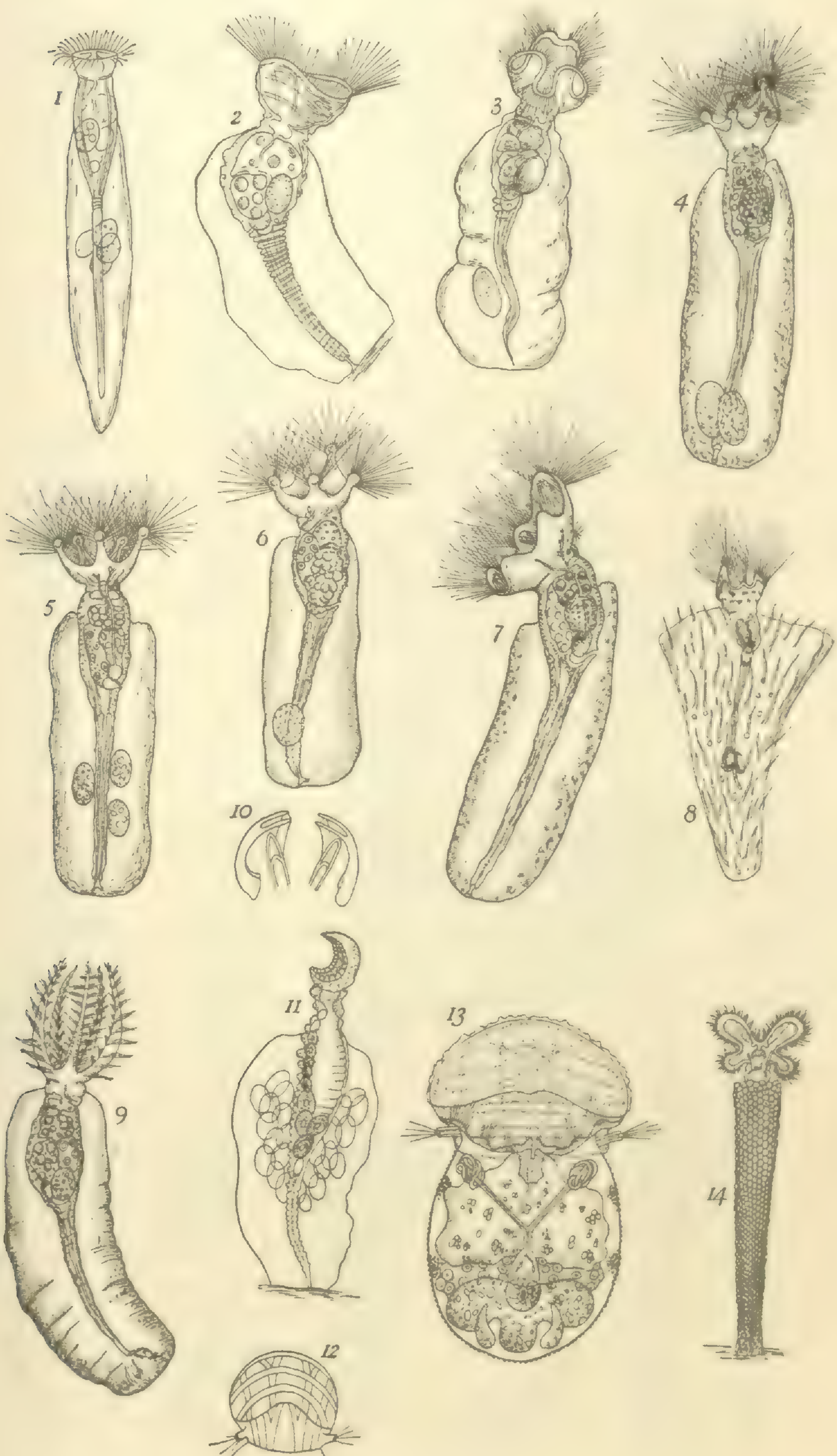

PLATE I.

LIST OF FIGURES—PLATE II.

15. Melicerta ringens, removed from tube, after Weber.
16. " " , jaws, after Hudson and Gosse.
17. " conifera, after Hudson and Gosse.
18. " janus, after Hudson and Gosse.
19. Limnias annulatus, after Weber.
20. Cephalosiphon limnias, after Weber.
21. Œcistes melicerta, side view.
22. " crystallinus, after Hudson and Gosse.
23. " intermedius, after Hudson and Gosse.
24. Megalotrocha semibullata, after Weber.
25. " alboflavicans, upper part, after Hudson and Gosse.
26. Conochilus volvox, after Hudson and Gosse.
27. " unicornis, after Weber.
28. Rotifer macroceros, after Weber.
29. " neptunius, after Weber.
30. " vulgaris (corona retracted), after Weber.
31. Foot of Rotifer trisecatus, after Weber.
32. " " " elongatus, after Weber.
33. " " " tardus, after Weber.

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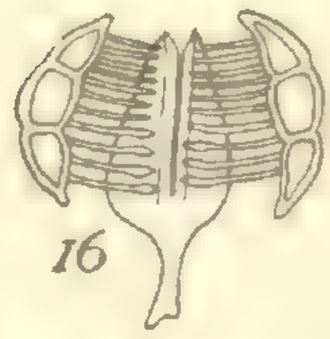

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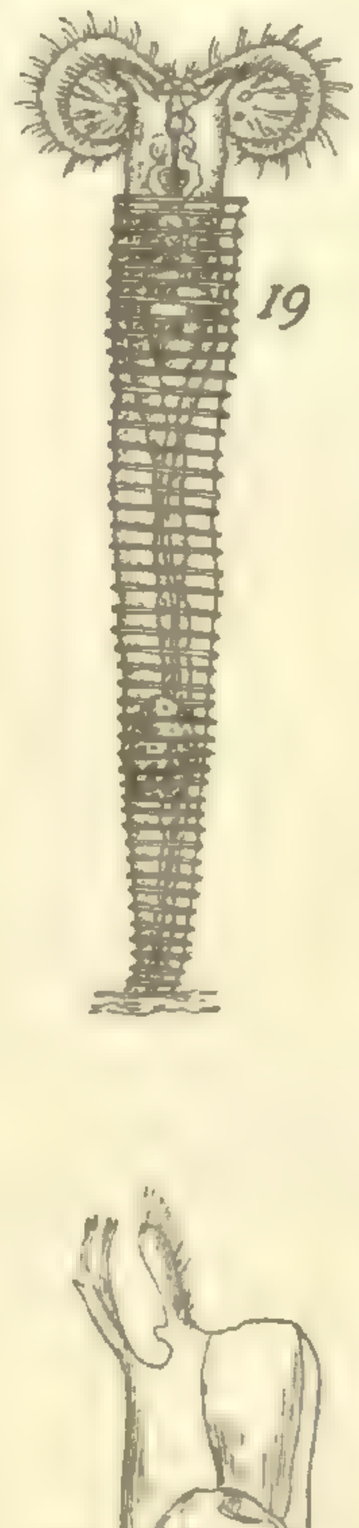

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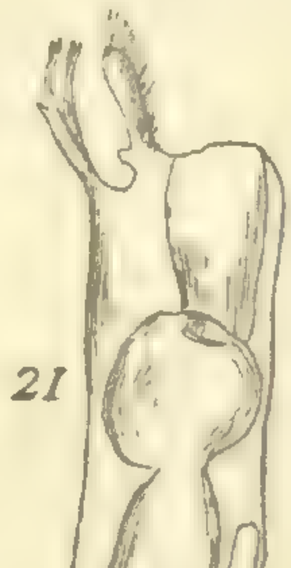

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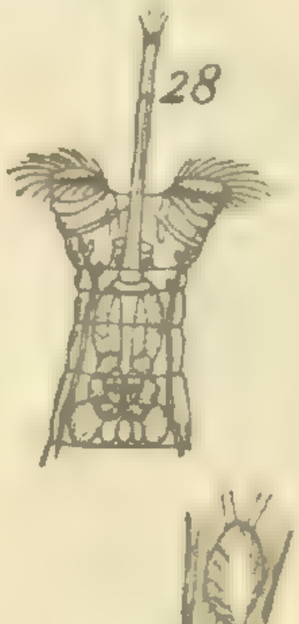

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PLATE II.

LIST OF FIGURES—PLATE III.

34. Jaws of Philodina aculeata (ramate type), after Weber.
35. Philodina megalotrocha, after Weber.
36. Callidina eremita.
37. " papillosa, after Janson.
38. " elegans, jaws, after Janson.
39. " constricta, jaws, after Janson.
40. " " , spurs, after Janson.
41. " socialis, spurs, after Janson.
42. " musculosa, jaws, after Janson.
43. " " , spurs, after Janson.
44. Adineta vaga, anterior end, after Weber.
45. Microcodon clavus, after Weber.
46. Notommata monopus.
47. Rhinops vitrea, anterior end, after Hudson and Gosse.
48. Pedalion mirum, after Weber.
49. Polyarthra platyptera, after Ehrenberg.
50. Triarthra longiseta, after Ehrenberg.
51. Asplanchnopus myrmeleo, after Weber.
52. Asplanchna ebbesbornii, side view, after Hudson and Gosse.
53. " herrickii, after Wierzejski.
54. " brightwellii, jaws (incudate type), after Wierzejski.
55. " girodi, jaws, after Wierzejski.
56. Ascomorpha hyalina, after Kellicott.
57. " ecaudis, after Hudson and Gosse.

PLATE III.

LIST OF FIGURES — PLATE IV.

58. Anarthra aptera, after Hood.
59. Synchæta stylata, after Wierzejski.
60. " tremula, after Hudson and Gosse.
61. Triphylus lacustris, after Western.
62. Cyrtonia tuba, after Rousselet.
63. Hydatina senta, after Weber.
64. Notops clavulatus, after Hudson and Gosse.
65. " pelagicus.
66. Taphrocampa saundersiæ, after Hudson and Gosse.
67. " annulosa, after Hudson and Gosse.
68. " selenura, toes, after Hudson and Gosse.
69. Copeus copeus, after Ehrenberg.
70. " pachyurus, after Weber.
71. " cerberus, after Hudson and Gosse.
72. " americanus, after Pell.
73. Notommata tripus, after Stokes.
74. " brachyota, after Weber.
75. " truncata.
76. " collaris, after Ehrenberg.
77. " aurita, after Hudson and Gosse.

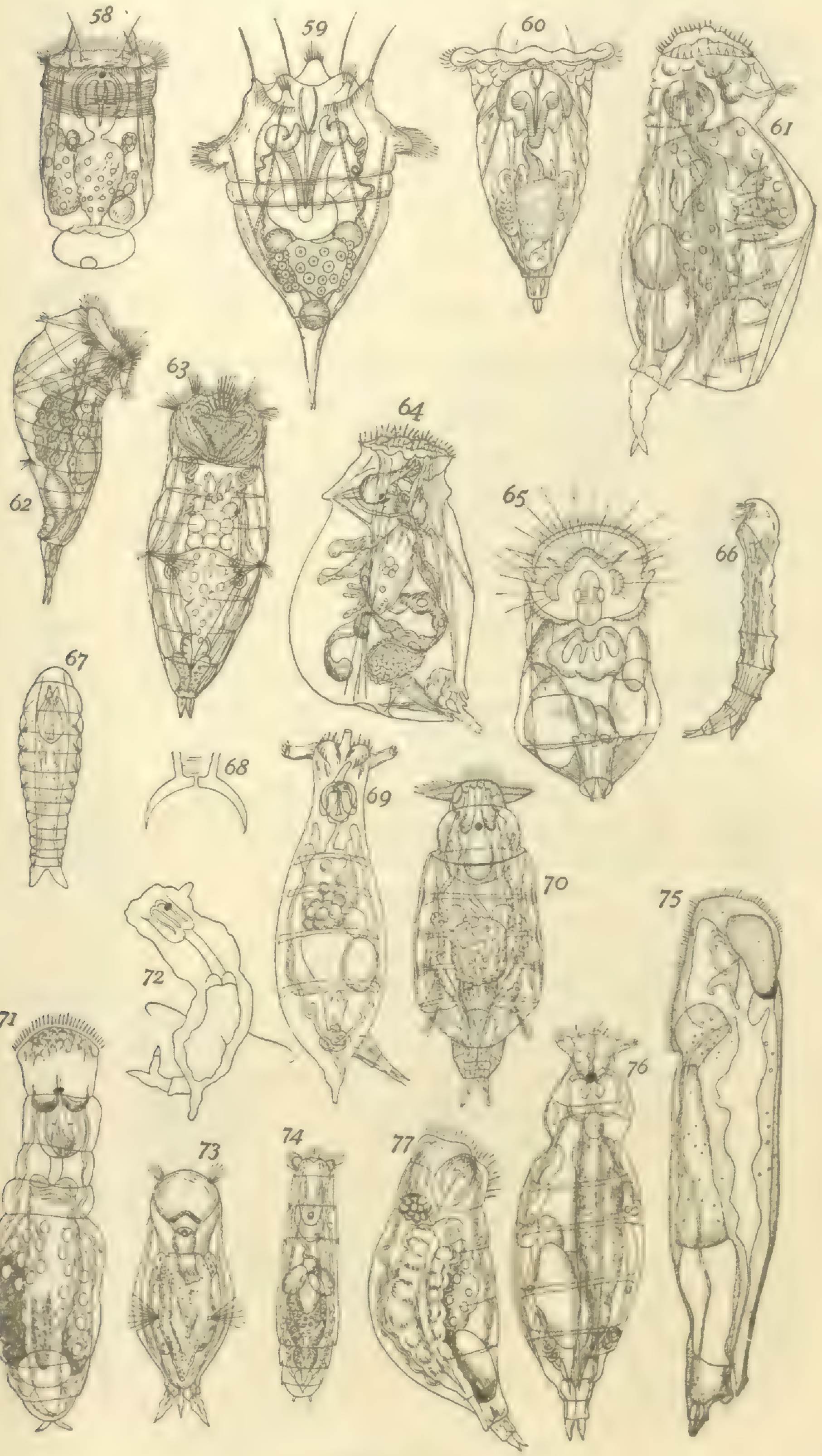

PLATE IV.

LIST OF FIGURES—PLATE V.

78. Notommata cyrtopus, after Hudson and Gosse.
79. " torulosa, after Cohn, from Hudson and Gosse.
80. Proales felis, after Hudson and Gosse.
81. " sordida, after Hudson and Gosse.
82. " micropus, after Hudson and Gosse.
83. " decipiens, after Weber.
84. " gibba, after Ehrenberg.
85. Furcularia forficula, after Weber.
86. " gracilis, after Hudson and Gosse.
87. " gibba, after Ehrenberg.
88. Triophthalmus dorsualis, after Ehrenberg.
89. Eosphora aurita, after Ehrenberg.
90. Diglena grandis, after Hudson and Gosse.
91. " forcipata, after Ehrenberg.
92. " circinator, after Hudson and Gosse.
93. " caudata, after Hudson and Gosse.
94. " catellina, after Weber.
95. " biraphis, after Hudson and Gosse.
96. Anapus ovalis.
97. Anuræa hypelasma, after Hudson and Gosse.
98. " cochlearis, after Weber.
99. " aculeata, after Hudson and Gosse.
100. Notholca longispina, lorica, after Hudson and Gosse.
101. Pterodina patina, after Hudson and Gosse.
102. " reflexa, after Rousselet.

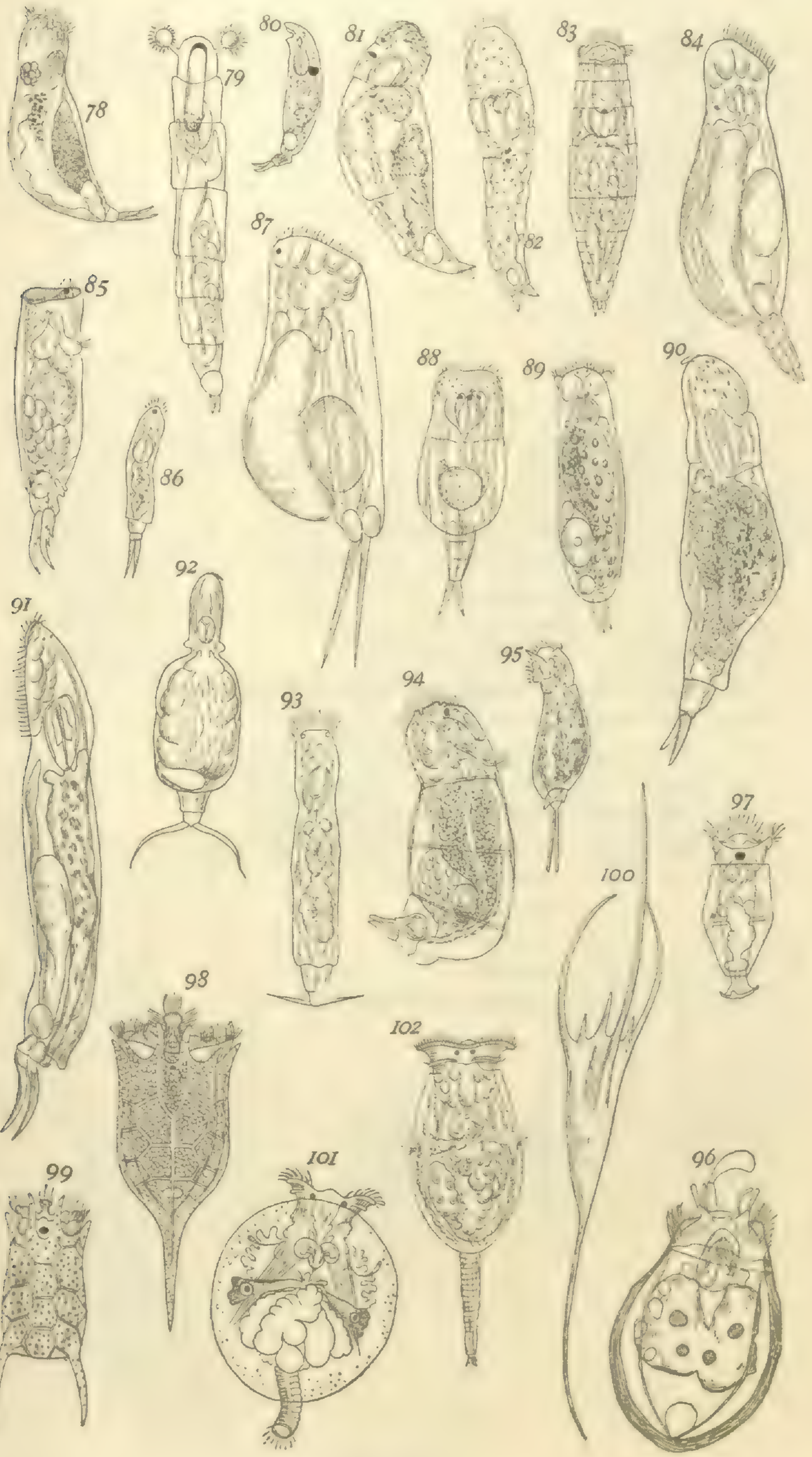
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PLATE V.

LIST OF FIGURES—PLATE VI.

103. Brachionus bakeri.
104. " punctatus, after Hempel.
105. " mollis, after Hempel.
106. Pleosoma lenticulare, after Wierzejski.
107. " truncatum, after Weber.
108. " hudsoni, after Wierzejski.
109. Gastropus stylifer, after Weber.
110. Noteus quadricornis, after Hudson and Gosse.
111. Polychætus subquadratus.
112. Stephanops longispinatus, after Weber.
113. Brachionus (?) gleasonii, after Vorce, from Hudson and Gosse.
114. Stephanops lamellaris, after Weber.
115. Mastigocerca carinata.
116. " elongata.
117. " bicristata.
118. " mucosa.
119. " bicornis.
120. " birostris, after Minkiewicz.

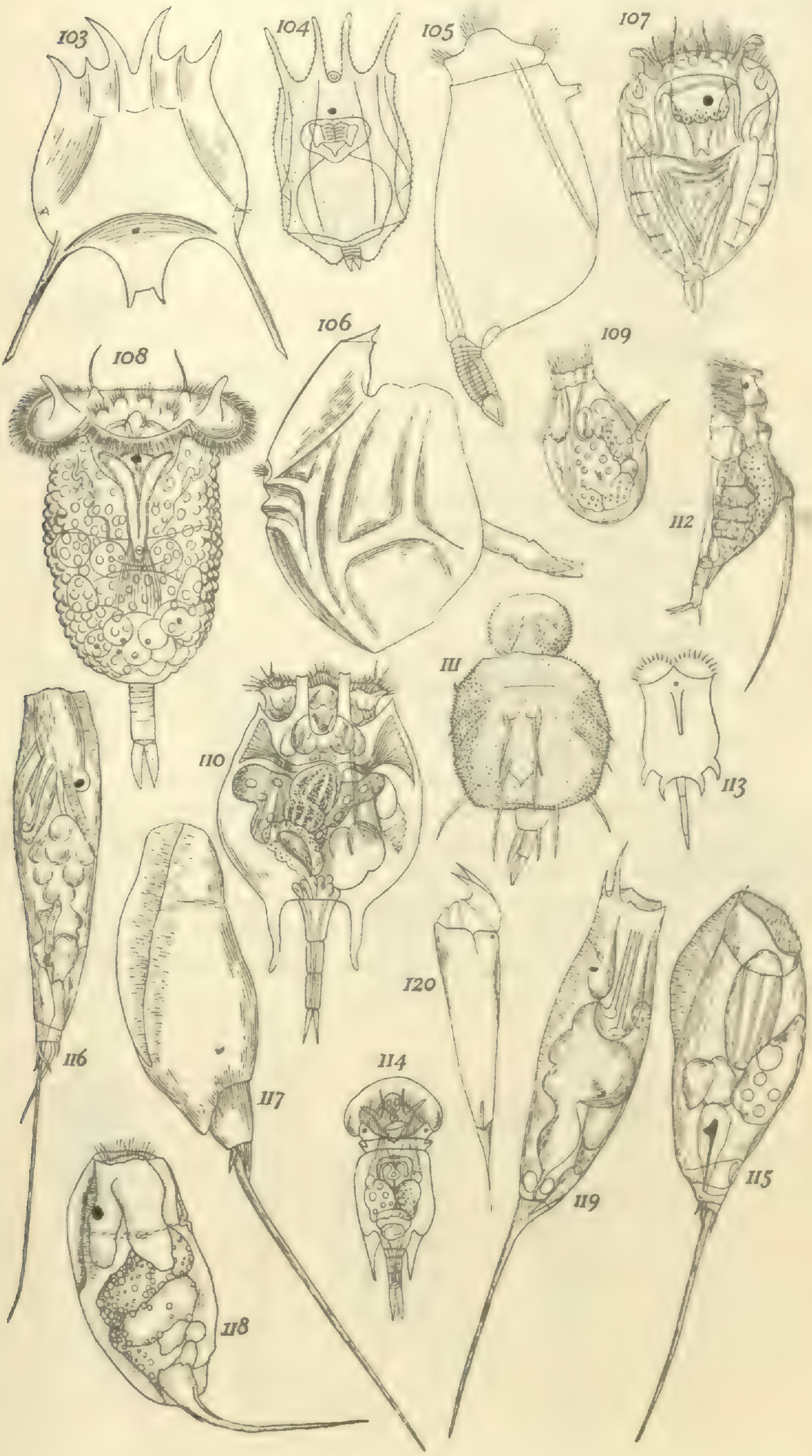
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PLATE VI.

LIST OF FIGURES—PLATE VII.

121. Mastigocerca capucina, after Wierzejski.
122. " multicrinis, after Kellicott.
123. " lata.
124. " bicuspes.
125. Rattulus tigris.
126. " sulcatus.
127. Coelopus (?) porcellus.
128. " brachyurus.
129. Diaschiza lacinulata, after Weber.
130. " semiaperta, after Hudson and Gosse.
131. Salpina mucronata, after Hudson and Gosse.
132. " eustala, after Hudson and Gosse.
133. " macrocera.
134. Dinocharis pocillum, after Hudson and Gosse.
135. Scaridium longicaudatum, after Weber.
136. " eudactylotum, after Hudson and Gosse.

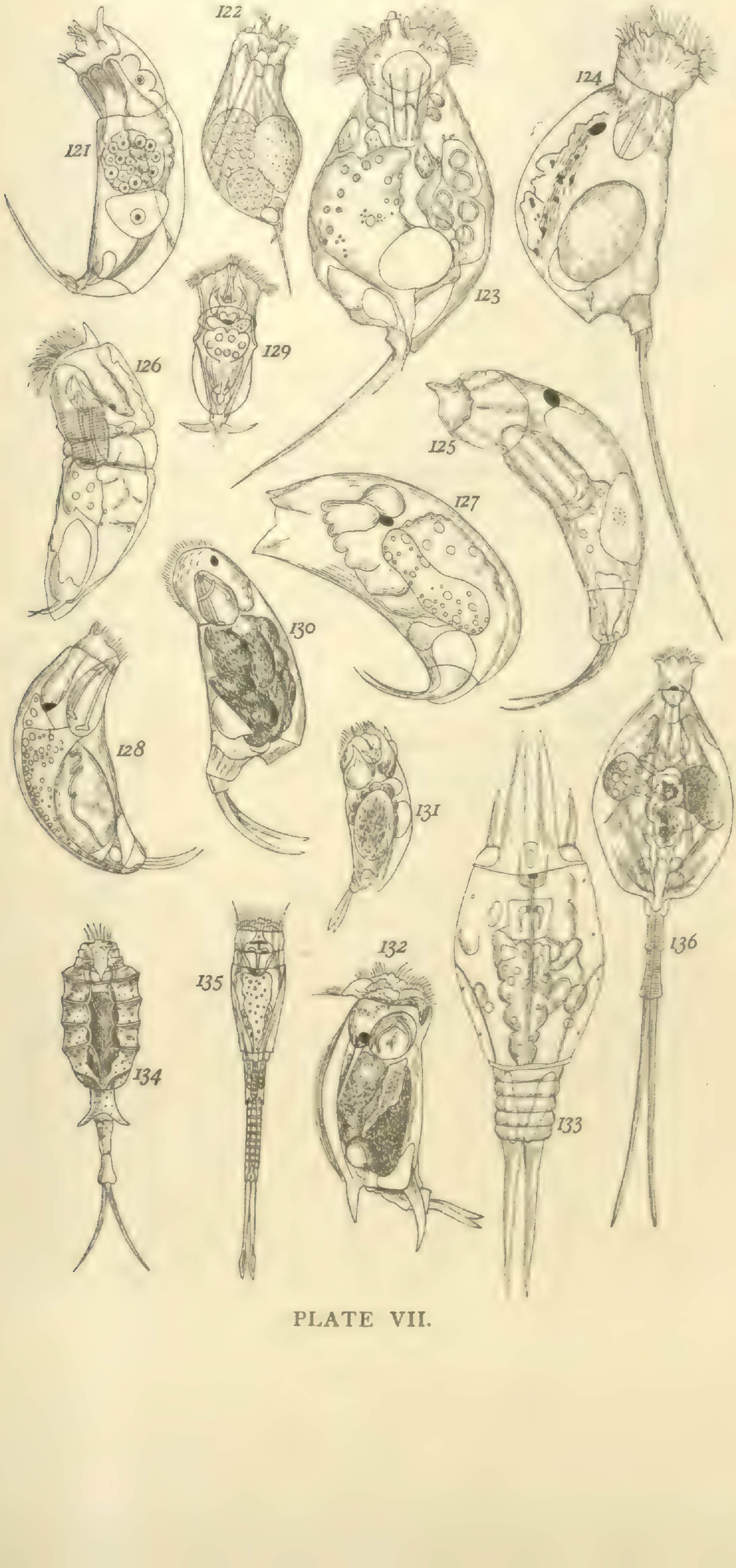

PLATE VII.

LIST OF FIGURES—PLATE VIII.

137. **Euchlanis dilatata, after Hudson and Gosse.**
138. " " , anterior dorsal edge of lorica, after Hudson and Gosse.
139. " **pyriformis, after Hudson and Gosse.**
140. " **ampuliformis, after Herrick.**
141. **Cathypna luna.**
142. " leontina.
143. **Distyla ohioensis.**
144. " stokesii.
145. " ludwigii.
146. " **spinifera, after Western.**
147. " **signifera.**
148. " **gissensis, partly extended.**
149. " " , retracted.
150. **Monostyla quadridentata.**
151. " closterocerca.
152. " lunaris.

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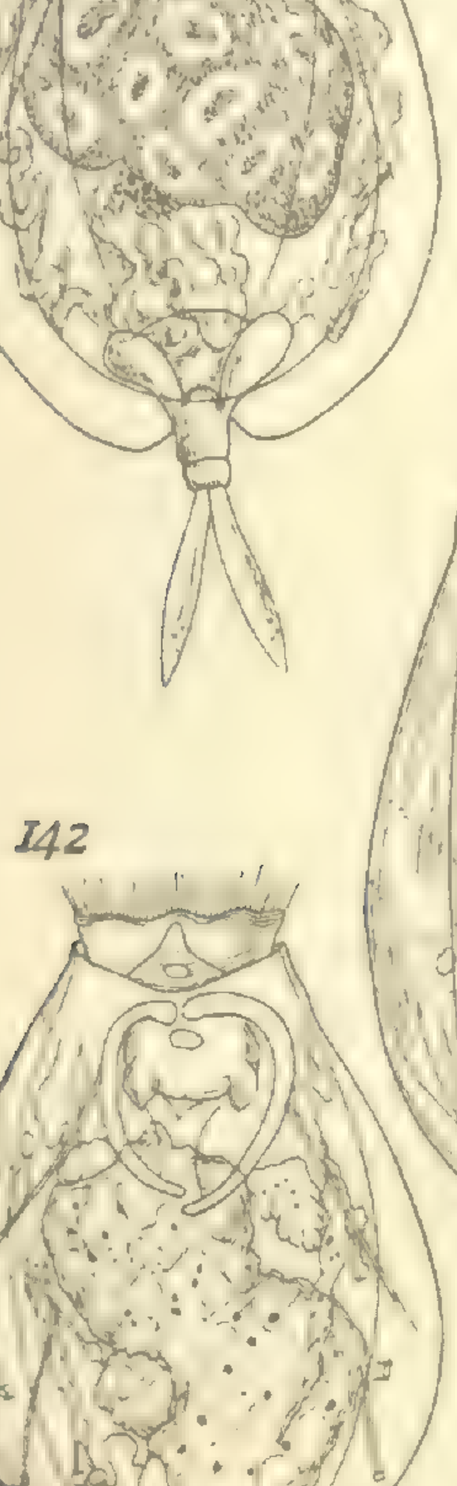

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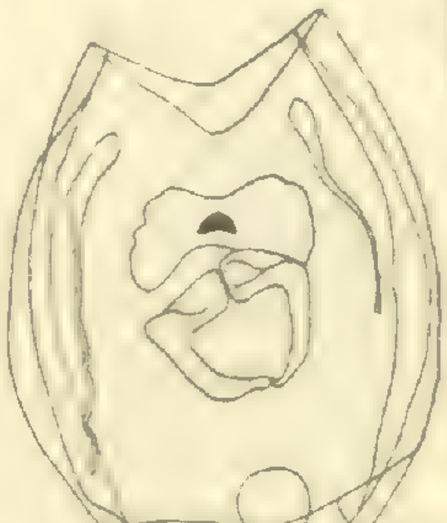

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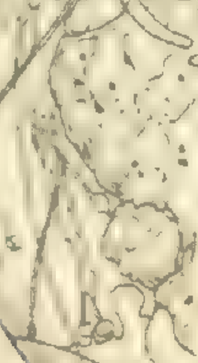

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PLATE VIII.

LIST OF FIGURES—PLATE IX.

153. Monostyla cornuta.
154. " bulla.
155. " arcuata.
156. " robusta, after Stokes.
157. Cochleare turbo, after Hudson and Gosse.
158. Colurus deflexus, after Hudson and Gosse.
159. " bicuspidatus, after Hudson and Gosse.
160. " obtusus, after Hudson and Gosse.
161. " agilis, ventral view of lorica, after Stokes.
162. " cristatus, after Rousselet.
163. Metopidia salpina, after Weber.
164. " lepadella, after Ehrenberg.
165. " oblonga, after Ehrenberg.
166. " dentata, after Turner.
167. " collaris, after Stokes.
168. " ehrenbergii.
169. " (?) cornuta, after Schmarda.
170. Malleate jaws, after Hudson and Gosse.
171. Forcipate jaws, after Hudson and Gosse.

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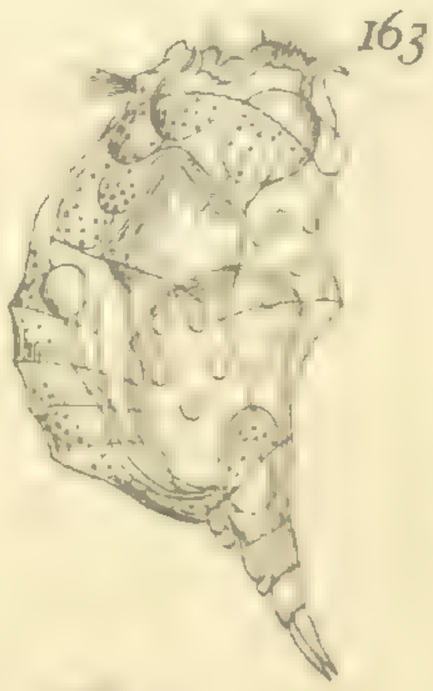
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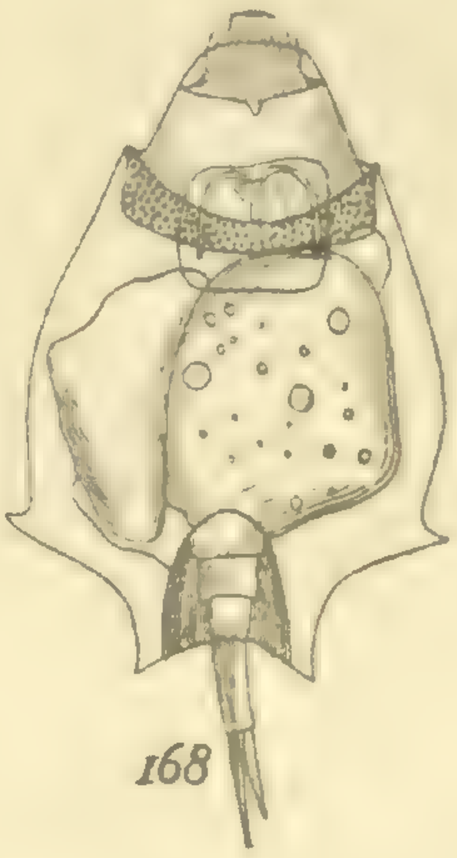
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PLATE IX.

REVIEWS OF RECENT LITERATURE.

ZOÖLOGY.

Reptilian Affinities of Primitive Mammals. — Sixta[1] has investigated the osteology of the foot in monotremes with the view of ascertaining the affinities of this primitive group of mammals. The monotremes possess a humerus with an epicondyloid foramen like that in reptiles, especially in the fossil Dimetrodon. Their radius, ulna, and carpal elements are arranged on the primitive reptilian plan, and yet their front feet are not unlike those of some marsupials (Dasyurus). In the hind foot the astragalus and calcaneum resemble those of reptiles, and the foot, on the whole, is oriented as in that group. The tarsals are as numerous as in the marsupials, but their forms and positions are typically monotrematic. The structure of the hind foot indicates an intermediate position for the monotremes between reptiles and marsupials. This opinion is further supported by a large body of evidence drawn from other organs, such as the heart and chief blood vessels (Hochstetter), the brain (Ziehen, Smith), the copulatory organs (Gadow), the embryonic membranes (Semon), the teeth (Poulton, Cope, Osborn), and skull.

P.

Anatomical Miscellanies. — The three numbers of the *Hopkins Hospital Bulletin*[2] for April, May, and June are combined into a single part and devoted to a collection of some twenty-three essays, mostly anatomical. The series opens with Barker's address on the Study of Anatomy, delivered at the Rush Medical College in October, 1900. Bardeen describes a new carbon-dioxide freezing microtome, Born's wax-plate reconstruction method as used in the Anatomical Laboratory at Hopkins, and calls attention to the importance of ordinary dissection-room material in scientific study. The cold-storage method of preserving bodies for dissection is dwelt

[1] Sixta, V. Vergleichend-osteologische Untersuchung über den Bau der Füsse der Reptilien, Monotremen, und Marsupialier, *Zool. Anzeiger*, Bd. xxiv (1901), pp. 321–332.

[2] *Bulletin of the Johns Hopkins Hospital*, vol. xii. Nos. 121–122, 123. April-May-June, 1901.

upon by Kerr. Harrison discusses the occurrence of tails in man, and reports on an interesting case brought to his notice by Dr. Watson. Brush contributes notes on cervical ribs, and Walker gives an account of cases of hereditary anchyloses of phalangeal joints. The development of the pig's intestine is described by MacCallum, and the structure of the gall-bladder by Sudler; of a less anatomical character are Halsted's report on the effects of injecting bile into the pancreas, and Opie's account of the etiology of acute hemorrhagic pancreatitis. The axillary artery and its variations are described by Hitzrot, the blood vessels of the lymphatic glands by Calvert, and the anatomical origin of the lymphatics in the liver by Mall, who also contributes a note on the basement membranes of the kidney tubules. Lewis gives an account of the pectoralis major muscle in man. The development of the human diaphragm is fully described by Mall. Neurology is represented by Mellus's article on the bilateral relations of the cerebral cortex, Long's paper on the development of the nuclei of the pons, and Fowler's description of a model of the dentate nucleus of the cerebellum. The development of the generative tracts in white ants is described by Knower, and the modification of normal menstruation by Mosher. The series gives substantial evidence of the great quantity and high quality of advanced work done in the Hopkins Hospital. P.

The Position of the Centrosome in Resting Cells. — By a thorough study of the segmenting eggs in Ascaris, zur Strassen[1] has shown that at each resting stage the centrosome takes up a position between the nucleus and the center of the exposed surface of the blastomere, *i.e.*, lies in the axis of the cell near its distal pole. This position is always attained, even though it involves a considerable migration on the part of the centrosome. As similar conditions have been figured by other authors in the segmenting eggs of several animals, and as the centrosome in ordinary epithelium regularly occurs in this position, zur Strassen believes that the rule discovered by him for Ascaris may prove to be of general application for all kinds of epithelial tissue, including the blastoderms of eggs. These observations favor the view that epithelial cells possess a true polarity, but this polarity is not one which has arisen first in adult epithelia. As is shown by its occurrence in the early segmentation stages, it is a polarity that is fairly comparable with that

[1] Zur Strassen, O. Ueber die Lage der Centrosomen in ruhenden Zellen. *Archiv für Entwickelungsmechanik der Organismen*, Bd. xii (1901), pp. 134–161.

of a flagellate protozoan cell, the ancestor of the colony of cells from which the metazoan body is believed to have taken its origin. Thus zur Strassen regards the polarity of epithelial cells not as a newly acquired feature, but as an inherited one derived from forms as primitive, possibly, as the protozoa. P.

The Intestine of Cetaceans. — Süssbach[1] has described in detail the structure of the intestine in a number of cetacean embryos recently collected by Kükenthal. In the toothed whales there is no division into a large and small intestine, and, except in Platanista, there is no cœcum present, structural conditions always observed in the baleen whales. The toothed whales always possess a simple mesentery, without any trace of the complications introduced in the baleen whales by the folding of the intestine about parts of the mesentery. The toothed whales have a relatively longer intestine than the baleen whales, but the configuration of the intestinal surface seems to be independent for the two groups; thus some of the toothed whales with short intestines have much the same kind of intestinal surface as that in the baleen whales, though a general rule was found to the effect that the shorter the intestine is, the more complicated are the folds on its surface. Notwithstanding this last circumstance, the condition of the intestine points to the complete separateness of the two groups of living cetaceans, the baleen and the toothed whales. P.

Notes on Recent Fish Literature. — In the *Proceedings of the California Academy of Sciences* (Zoöl., Vol. II, Nos. 7, 8) Jordan and Snyder describe two very remarkable new genera of Japanese fishes. The one, Ereunias (grallator), is a cottoid, allied to Triglops, but without ventrals, and with the four lowermost pectoral rays developed as detached feelers, as in Trigla. The other genus, Draciscus (sachi), is like Podothecus, but with enormously developed dorsal and anal fins. It belongs to the Agonidæ.

In the same *Proceedings* Jordan and Starks describe three new fishes from Japan, *Snyderina yamanokami*, *Pomacentrus cœlestis*, and *Heptranchias deani*. Snyderina is a new genus of Scorpænidæ, allied to Prosopodasys. All these species are represented by admirable plates, the work of Mrs. Chloe Lesley Starks.

[1] Süssbach, S. Der Darm der Cetaceen, *Jenaische Zeitschrift*, Bd. xxxv (1901), pp. 495–542, Taf. XVI, XVII.

In the *Abhandlungen der Senchenbergischen Naturforschenden Gesellschaft* of Frankfurt (Vol. XXV, No. 2), Dr. Steindachner gives an account of the fishes collected by Dr. Kükenthal in Molucca and Borneo. Two hundred and eight species are enumerated, six of them new, most of these being well figured.

In the *Records of Australian Museum* (Vol. IV, No. 1), Mr. E. R. Waite discovers that the sharks of the genera Hemiscyllium and Chiloscyllium bring forth their young alive. He therefore very properly separates these genera from the Scylliorhinidæ as a distinct family, Hemiscylliidæ. The genus Orectolobus (Crossorhinus) is also viviparous, and is recognized as a distinct family, Orectolobidæ. A figure is given of *Hemiscyllium modestum*, and also of the Australian dogfish, *Squalus megalops*, a species which has a very close relative in Japan.

As fishes of Lord Howe's Island, Mr. Waite figures *Upeneus pleurostigma*, *Apogon norfolcensis*, *Iniistius cacatua*, *Chætodon tricinctus*, and *Monacanthius homensis*. We may note that the deep green color of the teeth of *Pseudoscarus guacamaia* and related species is not the result of staining through the food. It is inborn, unvarying, and a result of distinct specialization.

D. S. J.

An Elementary Book on Lepidoptera.[1] — This is really an excellent book, both in conception and in execution. Reversing the order of her title, Miss Dickerson deals in Part I with the butterflies. The monarch *Danais archippus* holds the place of honor, and its life history and structural characters are given accurately and with sufficient detail; the other species, twelve in number, with the exception of two swallowtails, Papilios, a white, Pieris, and a sulphur, Colias, are all closely allied nymphalids.

In Part II *Callosamia promethea* is made the starting point, and the twenty and more species that follow are Bombyces, *sensu lat.*, and Sphinges.

The treatment in both these parts is so happy that the omission of an adequate account of the life history of a blue, Lycæna, and of a skipper, hesperid, among the butterflies, and of two or more of the lower moths, is especially regrettable.

Part III is divided between a chapter on relationship, showing classification and ancestry of moths and butterflies, and practical suggestions how to collect, keep, and study butterflies and moths.

[1] Dickerson, Mary C. *Moths and Butterflies.* Boston, Ginn & Company, 1901. xviii + 344 pp., 244 illustrations.

The chapter on relationship is from its nature more open to criticism ; it is, however, clear in statement and well balanced in proportion. The practical directions are adequate, though exception must be taken to the recommendation for mounting moths and butterflies in glass-covered tablets ; a sealed mount for any object preserved for study — and specimens not for study should not be collected — is undesirable.

A short list of books for reference, a glossary, and an index are also given.

Throughout the book errors of statement — such as, 'the tussocks are very often included, by competent authorities it is to be presumed, in the Noctuidæ,' and that there is but one brood of the white-marked tussock each year — are infrequent.

The illustrations are more numerous than either the title or the list indicates, and they show to what good advantage the camera may be applied in nature study. S. H.

Sesiidæ. — Mr. William Beutenmüller's long-expected monograph of the Sesiidæ of America north of Mexico appears in sumptuous form as Part VI of Vol. I of the *Memoirs of the American Museum of Natural History*. After a brief introduction there are sections on the position of the family, its characters, characters of the genera, synopsis of genera, historic review of generic names, habits of imago, mimicry of imago, characters of the larvæ, synopsis of larvæ, habits of larvæ, synopsis of food habits of larvæ, characters of pupæ, descriptions of genera and species with synopses of the species, and a bibliography.

Mr. Beutenmüller recognizes seventeen genera, 100 species, and ten varieties ; one new species and one new variety are described. Of the eight plates, five are devoted to the imagoes and three to larval borings. The figures of the imagoes, though inconveniently arranged on the plates, are admirable ; only five species and three varieties are unfigured. Text-figures showing structural details are also given.

A bibliography of more than thirty-five pages and with 542 titles would seem adequate, but is not sufficient to include all the works quoted in the body of the paper.

The date, March, 1901, on the cover is entirely unjustifiable : copies were not received until June, and were certainly not issued earlier than the end of May. S. H.

Mosquitoes. — Dr. Howard's well-known interest in and practical studies of mosquitoes take form in a volume [1] that will be of great value to naturalists, physicians, and municipalities. After a brief introduction he treats, in turn, with mosquitoes in general, malaria and mosquitoes, the common mosquitoes of the genus Culex, the malarial mosquitoes of the genus Anopheles, mosquitoes and yellow fever, mosquitoes and filiariasis, other genera of North American mosquitoes, natural enemies of mosquitoes, remedies against mosquitoes, how to collect and preserve mosquitoes, and the classification of the United States mosquitoes.

Dr. Howard's style is clear and direct, though a little inclined to redundancy and to repetition. An occasional lack of precision of expression and of accuracy may be noted ; mosquitoes, for instance, being held to include species that are not Culicidæ, and again to exclude forms always comprised within that family. Chapter VI, dealing with genera of North American mosquitoes other than Culex and Anopheles, mentions six "genera known to occur in the United States," but considers and refers to seven !

The illustrations are excellent ; a few are original, but the greater number from the facile pencil of Miss Sullivan appeared in the Author's *Notes* in 1900. Figure 42 does not represent *Aëdes fuscus*, and in the *Notes* was attributed to *A. sapphirinus*.

S. H.

BOTANY.

Bergen's Foundations of Botany [2] is virtually a much-improved and enlarged edition of the author's *Elements of Botany*, which has been one of the most successful of recent elementary text-books. The author's intimate knowledge of the needs and limitations of high schools, gained by long experience as a teacher, is shown even more effectively in the present volume than in its predecessor, for the publishers have done their part much better than before, improving the illustrations as well as adding largely to their number and in other ways doing fuller justice to the plan of the book.

[1] Howard, L. O. *Mosquitoes.* How they live ; how they carry disease ; how they are classified ; how they may be destroyed. New York, McClure, Phillips & Co., 1901. xv + 241 pp., pl., 50 figs.

[2] Bergen, Joseph Y., Instructor in Biology, English High School, Boston. *Foundations of Botany.* Boston, Ginn & Company, 1901. 12mo. xii + 412 + 257 pp., 12 pls., 306 figs.

A first part deals with the structure, functions, and classification of plants. Beginning with the seed and its germination, this part treats comparatively of the various organs of seed plants as regards their gross anatomy, histology, and physiology, then considers various types of cryptogams, and finally outlines the evolutionary history of the vegetable kingdom. Following this comes a part devoted to ecology, which ends with a brief discussion of the causes of organic evolution. The last third of the book consists of a key and flora in which are described nearly seven hundred species of plants available for study in the springtime. A *Handbook for the Use of Teachers* is published separately. This includes sixty-two pages of practical suggestions and references supplementary to the numerous directions for observations, experiments, and extra reading which are given in the text-book itself.

The book abounds in fresh, interesting facts illustrating the principles discussed. These, too, are presented in a way to be intelligible and significant to young people. It will lead them to many intellectual delights.

Comparatively few errors have been noticed, and these are for the most part such as will be readily detected by teachers who use the book. They may be misled, however, by the unqualified adoption of the calyx-adnate theory of inferior ovaries given in Chapters XV and XVIII. To say the least, this complicated view of the morphology of many flowers and fruits is open to serious question. The modern view which regards an inferior ovary simply as one imbedded in the torus accords much better with what is known of the development of flowers, and avoids much perplexity to the student of flower and fruit morphology.

FREDERICK LEROY SARGENT.

Notes. — Professor Jepson's *Flora of Western Middle California* (Berkeley, Cal., 1901, iv + 625 pp.), which covers a region already locally handled, is really an expression of the author's own success in a field recognition of species, and, as he is conscientious and has drawn up his descriptions from fresh material instead of compiling them or basing them on herbarium fragments, the book should be helpful.

Dennert's *Plant-life and Structure*, translated from the German by Clara L. Skeat, forms one of the "Temple Primers," of which The Macmillan Company are the American publishers. It is easier to say why some books see the light than others. This little book belongs in the second category.

Dr. Robinson's latest "Contribution from the Gray Herbarium of Harvard University," constituting No. 26 of the current volume of *Proceedings of the American Academy of Arts and Sciences*, includes synopses of Melampodium and Nocca (or Lagascea), and a number of additions to the Mexican flora, chiefly in the genus Eupatorium.

An enumeration of the plants known to grow on Mt. Rainier, by Piper, is published in *Mazama* for April. Flowering plants seem to disappear above 10,000 feet, at which elevation *Smelowskia ovalis* still occurs, and the timber line is at 6500 feet.

A considerable part of *Rhodora* for June is given to articles on Mt. Katahdin and its botany.

Fascicle 2 of the current volume of the *Mémoires de l'Institut Egyptien* is a contribution to the flora of Egypt, by E. Sickenberger. Though the fascicle bears date 1901, the preface is dated January 31, 1895.

Mr. J. M. Macouns's "List of the Plants of the Pribilof Islands," with notes on their distribution, has been reprinted from Part III of Jordan's *Fur Seals and Fur-seal Islands of the North Pacific Ocean.*

A paper on new spermatophytes from Mexico and Central America, by M. L. Fernald, constitutes No. 27 of the current volume of *Proceedings of the American Academy of Arts and Sciences.*

A thirteenth selection of new plants from Wyoming, by Aven Nelson, is published in the *Bulletin of the Torrey Botanical Club* for April.

The third of a numbered series of papers which Professor Sargent is publishing in the *Botanical Gazette* under the title "New or Little-known North American Trees," in the April number of that journal, adds a considerable number of species of Cratægus for the United States, and a new Alaskan Betula, and raises the Californian *Cupressus Goveniana pygmæa* to specific rank.

The forms commonly referred to *Ribes rubrum* have been passed in review by Hedlund in recent numbers of *Botaniska Notiser.*

The native plums form the subject of *Bulletin No. 87* of the Wisconsin Experiment Station, by Professor Goff.

A revision of thirty-five western and northern Antennarias of the plantaginifolia set, by Elias Nelson, has recently been separately distributed from the *Proceedings of the United States National Museum.*

Anatomical studies of Primulaceæ and Simarubeæ are contained in recent numbers of the *Annales des Sciences Naturelles.*

The Gardener's Chronicle for June 8 contains an illustrated article on the species of Platanus usually planted as street trees, etc.

The morphology and anatomy of Aloineæ is the subject of an illustrated paper by Hausen in the *Verhandlungen des Botanischen Vereins der Provinz Brandenburg* for 1900.

The grasses of Iowa are considered at length as to their biology, chemical composition, etc., by Pammel, Weems, and Lamson-Scribner, in *Bulletin No. 54* of the Iowa Agricultural College.

Professor Lamson-Scribner gives an account of some Arizona grasses — several of them described as new — in *Circular No. 32* of the Division of Agrostology of the United States Department of Agriculture.

A revised edition of *Bulletin No. 17* of the Division of Agrostology of the United States Department of Agriculture (Professor Lamson-Scribner's "American Grasses, II") has been issued from the Government press.

Mr. C. L. Shear publishes some notes on Fournier's Mexican species and varieties of Bromus in the *Bulletin of the Torrey Botanical Club* for April.

The coralloid rootlets of *Cycas revoluta* and their symbiosis are considered by A. C. Life in the *Botanical Gazette* for April.

Professor Shimek contributes a paper on the pteridophytes of Iowa to the current volume of the *Bulletin* of the laboratories of natural history of the State University of Iowa.

The eighty-two Alaskan Hepaticæ noted in Professor Evans's paper on the representatives of this group collected by the Harriman Expedition are increased by the addition of three others collected by Professor Setchell, in a list of species published in Nos. 6, 7 of *Zoe.*

A third series of preliminary diagnoses of new species of Laboulbeniaceæ, by Dr. Thaxter, is issued as No. 23 of the current volume of *Proceedings of the American Academy of Arts and Sciences.*

A convenient pocket host index for the commoner European parasitic fungi, by Dr. Lindau, is published by Gebrüder Borntraeger, of Berlin.

A revision of forty species of Hydnum, by H. J. Banker, appears in the April number of the *Bulletin of the Torrey Botanical Club.*

A report on the agricultural resources and capabilities of Hawaii, by Professor Stubbs, which constitutes *Bulletin No. 95* of the Office of Experiment Stations of the United States Department of Agriculture, contains reproductions of a number of excellent photographs of tropical plants and fruits.

The cultivation and manufacture of tea in British India and Ceylon is the subject of No. 2 of the current volume of *Beihefte zum Tropenpflanzer*, published in Berlin.

An illustrated article on breeding new wheats, at the Minnesota Experiment Station, is a prominent feature of *The World's Work* for May.

The manufacture of sago is illustrated in *Der Tropenpflanzer* for May.

"The Stock-poisoning Plants of Montana" is the title of an extensive illustrated paper by Chesnut and Wilcox, published as *Bulletin No. 26* of the Division of Botany of the United States Department of Agriculture.

The third volume of *Meddelanden fraan Stockholms högskolas botaniska institut* — an assembled series of papers by Professor Lagerheim and his associates — is especially interesting because of its mycological contents.

An illustrated catalogue of the plants of the Alpine garden "La Linnæa," of Bourg-St.-Pierre, has recently been issued by the director, M. Correvon, of Geneva.

An account of the botanic garden of the Czernowitz University, planted in 1877, is contained in the *Festschrift* of the recently celebrated quarter-centennial of the University.

A short illustrated article on the botanic gardens of Malta is published in the *Gardener's Chronicle* for May 4.

The *Youth's Companion*, than which no more potent medium could be desired, has undertaken to aid in creating a national sentiment which shall eventually result in the universal beautifying of the grounds of the rural schools of the United States.

CORRESPONDENCE.

Editor of the American Naturalist:

SIR, — In the course of recent bibliographical studies the writer has discovered a number of cases in which the names given to recently described American hydroids have been given to other species by previous writers. For three of these the writer is personally responsible, and takes the first opportunity to correct the errors. The other cases will be discussed later.

Halecium geniculatum Nutting. Hydroids from Alaska and Puget Sound. *Proceedings of the United States National Museum*, Vol. XXI, p. 744.

This name was used by Norman in a paper published in 1866, entitled "On the Hydrozoa (etc.) of the Hebrides," p. 196.

For this species the following name is now proposed: *Halecium washingtoni* Nutting.

Halecium robustum Nutting. Papers from the Harriman Alaska Expedition, XXI. The Hydroids, 1901, p. 182.

Allman gave this name to a species from Kergueland Bay. *Challenger Report.* The Hydroida, Part II, 1888, p. 10.

For this species I propose the following name: *Halecium harrimani* Nutting.

Thuiaria elegans Nutting. Papers from the Harriman Alaska Expedition, XXI. The Hydroids, 1901, p. 187.

Name preoccupied by Kirchenpauer. Nordische Gattungun und Arten von Sertulariden, 1884, p. 21.

This species will now be known as *Thuiaria kincaidi* Nutting. Named in honor of Mr. Trevor Kincaid, one of the members of the Harriman Expedition.

Judging from the numerous cases that have recently come to my attention of the use of preoccupied names in zoölogy, I am more and more of the opinion that it is unsafe to give descriptive specific names to forms belonging to long-established genera. It is safe to say that no one investigator has at his command all of the papers relating to any group of considerable size. The names which occur to a writer as particularly apt in a descriptive way are the very ones that have been most likely to appeal to previous writers.

C. C. NUTTING.

UNIVERSITY OF IOWA, July 13, 1901.

(*No. 416 was mailed August 22.*)

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THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

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All naturalists who have anything interesting to say are invited to send in their contributions, but the editors will endeavor to select for publication only that which is of truly scientific value and at the same time written so as to be intelligible, instructive, and interesting to the general scientific reader.

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THE
AMERICAN NATURALIST

VOL. XXXV. *October, 1901.* No. 418.

THE COMPOUND AND MIXED NESTS OF AMERICAN ANTS.

WILLIAM MORTON WHEELER.

PART III. SYMBIOGENESIS AND PSYCHOGENESIS.

"Eine Psychologie in Spencer-Darwin'schem Sinne auf Entwicklungslehre gegründet, aber auf positiver Detailforschung fussend, verspricht reichere Resultate als alle bisherigen Speculationen." — E. MACH.

ALL writers on the behavior of ants have been deeply impressed with the cases of social symbiosis, more especially with those of an extreme type like Polyergus and Anergates. The deadly animosity of the members of a formicary, not only towards ants of another species but even towards ants of the same species belonging to different colonies, is so striking and so nearly universal that an extraordinary explanation seems to be demanded to account for the cases of amicable consociation of two species. In the presence of such phenomena, instinct and consentience, or sense-experience, have been abandoned as inadequate, and the existence in ants of some higher form of intelligence, like understanding and ratiocination, has been postulated without further ado. At the same time the evolutionist has been stimulated to broach a phylogeny of social

symbiosis. Both the stress laid on the psychical manifestations of ants and the attempts at establishing a phylogeny of the compound and mixed nests have been clearly apprehended and set forth in considerable detail by Wasmann ('**91**). While my own observations lead me to agree with this able investigator in many respects, I must, nevertheless, dissent from his attitude towards the genetic method as applied to the study of the compound and mixed nests. It is necessary, therefore, to attempt a critical revision of this matter so far as this is possible within the limits of the present paper. I shall deal first with phylogeny as applied to the cases of social symbiosis and conclude with a very brief consideration of some of the pertinent psychical problems.

Darwin was the first to attempt an explanation of the origin of dulosis in the European ants. In a well-known passage in the "Origin" ('**61**, p. 244) he says: "By what steps the instinct of *Formica sanguinea* originated I will not pretend to conjecture. But as ants, which are not slave-makers, will, as I have seen, carry off pupæ of other species, if scattered near their nests, it is possible that such pupæ originally stored as food might become developed; and the foreign ants thus unintentionally reared would then follow their proper instincts, and do what work they could. If their presence proved useful to the species which had seized them — if it were more advantageous to this species to capture workers than to procreate them — the habit of collecting pupæ originally for food might by natural selection be strengthened and rendered permanent for the very different purpose of raising slaves. When the instinct was once acquired, if carried out to a much less extent even than in our British *F. sanguinea*, which, as we have seen, is less aided by its slaves than the same species in Switzerland, natural selection might increase and modify the instinct — always supposing each modification to be of use to the species — until an ant was formed as abjectly dependent on its slaves as is the *Formica rufescens*."

Apart from the statement that the English and Swiss *sanguinea* differ in their behavior — a statement which has been since disproved — Darwin's views have been accepted by Forel

('74, p. 440), who has also called attention to the fact that the frequent occurrence of pupæ without cocoons in the nests of *F. fusca* would add to the plausibility of Darwin's hypothesis, for such free pupæ would be able to hatch without the assistance of the enslaving species.[1]

Pursuing Darwin's line of thought, Forel ('74, p. 443) called attention to the following series, which seems to have been previously in great part suggested by von Hagens ('67): "1. Working ants pure and simple; 2. ants dwelling in abnormal mixed colonies; 3. *F. sanguinea* (sometimes without slaves); 4. *Polyergus rufescens* (here the working instinct, which is merely diminished in *F. sanguinea*, disappears completely and the slave-making instinct attains its apogee); 5. *Strongylognathus huberi* (the slave-making instinct is certainly still alive); 6. *S. testaceus* (the slave-making instinct no longer exists except in the form of derisory vestiges, the worker is on the road to atrophy and tends to disappear); 7. *Anergates atratulus* (the worker has disappeared; only parasitism is admissible). This last ant, it seems to me, is a remarkable example of reversion to ancestral traits (incomplete societies, without workers) through parasitism; its genealogy is explicable through *S. testaceus*, the workers of which have become so rare in comparison with the females and males." Essentially the same series of cases was adopted by Lubbock ('94, pp. 88, 89). At the present time it could be still further perfected, as Wasmann suggests, by the insertion of *Tomognathus sublævis* between *F. sanguinea* and Polyergus.

The views initiated by Darwin have not been allowed to pass unchallenged. The first to take up the cudgels was McCook in the concluding paragraphs of his paper on *Polyergus lucidus* ('80, pp. 383, 384). After presenting Darwin's views he writes: "Whatever credit we may give to this ingenious hypothesis, it must be said that in the case of our *F. schaufussi*, natural selection has not operated to degenerate the soldierly courage and faculty, and remand the duty of defense to those associates in whom the military faculty

[1] The American slaves of *F. sanguinea* and Polyergus, *viz.*, *F. fusca*, vars., *subsericea* and *subænescens*, and *F. nitidiventris* also often have free pupæ.

has been specialized. In other words, if Lucidus has become specialized as a warrior, dropping an original disposition and ability to labor, her slave has not become specialized as a worker, nor dropped her combative faculty, but seems to be possessed in all respects of the normal habits and nature of ants of her species. At least I could trace in her no effects of slavery, other than the strange association with and care of her abductor. One, therefore, who accepts Dr. Darwin's suggestion, must allow that natural selection has wrought toward specialization in one section of the colony, but has been suspended in its operations upon the other section. It is doubtful if the anomalous conditions thus raised by Dr. Darwin's explanation be not more difficult to explain than the original conditions to which the hypothesis was applied."

Assuredly, if all the arguments against natural selection were as easily refuted as the one here produced by McCook, Darwin's followers would have occasion for great rejoicing. The refutation is equally easy whether we consider the colonies of the auxiliary species with which Polyergus wars, or only the larvæ and pupæ which it abducts from these colonies and rears as its slaves. So far as the latter are concerned, McCook has completely overlooked the very obvious fact that Polyergus rears only the workers of the auxiliary species, and these have never been known to reproduce in the mixed nests. But even if we suppose, for reasons to be given below, that these workers may often reproduce normally, the difficulty is not removed, since they would not only have to be able to transmit characters acquired in their imaginal stage, — and the possibility of this has by no means been demonstrated, — but they would have to transmit these characters to male or female offspring if there was to be any permanent modification of the species. Now this is impossible, because Polyergus will not permit the winged sexes of the auxiliary species to reach maturity. Hence the detached auxiliaries cannot impart any modifications to the species to which they belong, no matter what peculiarities they may take on in the Polyergus nests.

Though the fallacy in McCook's argument is very obvious, Wasmann still contends that it involves "einen vorzüglichen

Gedanken," which he puts in the form of the following question: "If natural selection can bring about such a peculiar development of the instincts in the dominant species, why has it not exercised a corresponding influence over the enslaved species?" Wasmann is evidently bent on rescuing that portion of the argument not expressly stated by McCook, *viz.*, the necessity of a change of character in the ants of the colonies attacked by Polyergus. But closer inspection shows this attempt to be unsuccessful, for he has not considered the question of the relative abundance of the dominant and auxiliary species. That this is a matter of some moment in a discussion of this kind is seen from a general survey of parasitic and predaceous organisms. These must of necessity live on that margin of surplus vitality and reproductivity so characteristic of all animals and plants; for it is obvious that organisms which depend very decidedly for their sustenance on special hosts or prey must endanger their own existence to the extent that they endanger the existence of the species on which they depend. The serious injury or death of the host species implies the death of the parasitic species in all cases where the relations between the two are of a highly specialized character. This argument could be adduced if the Polyergus were more abundant or quite as abundant as the auxiliary species. But it is quite unnecessary to make use of it, because Polyergus is a rare ant of local occurrence, and the various forms of *F. fusca* and *F. pallide-fulva* which it enslaves are widely distributed and vastly more abundant both in colonies and individuals. In fact, no other insects are as common in our Northern States as the varieties of these two ants, and even in Texas, near the southernmost limits of the distribution of *F. fusca*, a form very closely related to *F. subsericea*, *viz.*, *F. gnava* Buckley, is the most prolific of ants. Its nests often contain upwards of thirty fertile queens, and the number of eggs, larvæ, and pupæ which are reared between the end of February and the first of June is enormous. Why, then, should these very prolific and widely distributed species exhibit a special development of valor or a particular defensive form of nest architecture in adaptation to a rare predaceous

ant of sporadic occurrence? As well might we expect the human dermis and its appendages to present hereditary modifications in adaptation to occasional parasites like *Pediculus capitis*. The advantages that would result from the development of a courageous disposition and specially protective forms of nest architecture in *F. fusca* and *pallide-fulva* are more than outweighed by those derived from their unusual powers of reproduction. These species run to offspring, not to valor. That the survival and even the predominance of species does not necessarily depend on the development of moral and psychic endowment is demonstrated on a grand scale in the vegetable kingdom.

This defense of McCook's argument is, however, only a small portion of Wasmann's criticism of the position held by Darwin, Forel, and Lubbock in regard to the phylogeny of the mixed colonies ('91, pp. 214–254). Wasmann sees in these same facts irrefutable arguments against the theory of indeterminate variation and natural selection, and arguments equally strong in favor of tracing the modicum of physical and psychical development which is acceptable to him to "innere gesetzmässig wirkende Entwicklungsursachen." In my opinion, he has succeeded — if indeed he has really succeeded — only in showing that the genetic method has been somewhat awkwardly applied to the cases of compound and mixed nests. On the whole, I believe that he has neither invalidated the principle of natural selection, nor made it perfectly clear that we must forthwith deliver ourselves up to anything so impalpable as "innere gesetzmässig wirkende Entwicklungsursachen." In support of these statements the following remarks on some of Wasmann's arguments are offered.

Wasmann seems to regard it as an established fact that worker ants do not reproduce, or do so only under unusual or even pathological conditions. He is also inclined to emphasize the differences between the instincts of the queens and those of the workers. Hence the workers are debarred from transmitting their peculiar characters, either congenital or acquired, and the instinct modifications, so characteristic of different species of ants, must be explained as arising from determinate,

internally regulated variations. The premises to these conclusions I cannot accept, since they do not appear to me to be indefectibly established. They are based on a rather limited study of a few species of highly specialized European ants, and cannot, therefore, lay claim to great generality. My own observations, still incomplete, to be sure, on several Texan ants representing both the most primitive and the most specialized subfamilies (Ponerinæ and Camponotinæ) convince me that worker ants not only very frequently lay eggs in considerable numbers, but that these produce perfectly normal offspring. When workers are properly fed in the artificial nests, they seem to have no more desire to devour their own eggs than to devour those which are deposited in their keeping by the queens. During February last a carefully isolated lot of workers and soldiers of a handsome Camponotus (*C. texanus* n. sp.) laid dozens of eggs in my Fielde nests. By the first week in June many of the larvæ were mature, and a few of these had spun their cocoons before I was compelled to leave my laboratory for the summer. These cocoons were found to contain perfectly normal male pupæ, thus adding fresh evidence for the generally accepted belief that the parthenogenetic offspring of worker ants are males. Similar observations were made on workers of *Camponotus marginatus* n. var. and Pachycondyla, except that in these cases I did not follow the larvæ quite to the pupal stage. I am, moreover, convinced that numerous eggs are laid (probably by the soldiers) and reared in the frequently queenless nests of a gall-inhabiting Colobopsis (*C. etiolata* n. sp.) from Texas. In fact, for aught we know to the contrary, every well-developed ant colony may contain one or more fertile workers. Where the worker caste is dimorphic the soldiers probably have the greatest tendency to lay eggs. Judging by analogy with other Hymenoptera, like Polistes among the wasps, it is also probable that the older and more vigorous the ant colony, the greater the tendency for workers to take on the reproductive powers of the queen. That these conditions clearly imply the possibility of the inheritance of worker characters through the male offspring goes without saying. The comparatively frequent development of

the reproductive power in worker ants makes it possible to account for the conditions presented by Leptogenys and Tomognathus. In these genera worker forms (ergatoids) have usurped the functions of the winged queens, which have completely disappeared.[1]

The statements of Wasmann and other authors concerning the differences between the instincts of the queens and workers seem to me to require some qualification. This difference is rather quantitative than qualitative, for the recently fertilized queen, even in highly specialized ants, during the establishment of her colony displays nearly all the worker instincts, even to excavating and defending the nest and caring for the first brood of young. In some species (Ponerinæ?) she may even exhibit the foraging instinct so characteristic of the workers, for aught we know to the contrary. It is true that in the more highly specialized ants like Formica, these instincts lapse into desuetude as soon as the workers make their appearance in the nest, but it is equally true that they may be retained throughout life as in the queens of the Ponerinæ, Leptothorax, and probably also many other ants. While I do not wish to lay unwonted stress on these fragmentary observations and reflections, they are, nevertheless, quite sufficient to bid us hesitate in the use of arguments which start from the assumption that the worker ants reproduce only under pathological conditions and present instincts essentially different from those of the queens.

Wasmann encounters the gravest difficulties in the genetic explanation of dulosis. His remarks are mainly confined to the two well-known cases, *Formica sanguinea* and Polyergus, the former, in the opinion of most writers, an incipiently, the latter a perfectly, dulotic species. He attempts to show that dulosis could not have arisen in *sanguinea* by selection, since flourishing or medium-sized colonies of this species could have derived no advantage from the possession of a small number of slaves, while the advantage that would accrue to a small colony

[1] Silvestri ('01), in a paper received while these paragraphs are going through the press, expresses some very similar views concerning the fecundity of worker Termites.

would be more than outweighed by the difficulty such a colony would experience in obtaining slaves.[1] And even if the dulotic habit had manifested itself repeatedly as a chance variation, and had proved useful, there would still be lacking the hereditary basis for the instinct, since this is exhibited only by the workers. Wasmann states the difficulty in the following words ('91 p. 236): "Before the inclination to rear slaves had proved itself permanently beneficial during many generations, it could not have been established by natural selection as an hereditary Anlage; but the possibility of inheriting the Anlage must exist before the incipient inclination could be transmitted from one colony to another — *ergo* natural selection lacks the very point of departure for the development of an hereditary slave-making instinct from the accidental forms of mixed colonies. We must leave natural selection like Baron von Münchhausen to drag itself out of the morass by its own hair."

Surely natural selection, however numerous its shortcomings, deserves better treatment at our hands. A careful perusal, however, of the above-quoted passage from the "Origin" and a consideration of the facts brought to light since its publication leave little cause for anxiety. Wasmann assumes that *sanguinea* robs the pupæ of other ants *for the sake* of rearing slaves. This is scarcely borne out by the facts. The young of the auxiliary species are sought for and appropriated to serve as food, in obedience to an ancient and widespread formicid instinct that emerges to view very clearly in many often distantly related species of ants. Thus Adlerz has shown ('96a) that on exceptional occasions even *Lasius niger* robs the larvæ and pupæ of *L. flavus*, and these may hatch and function as slaves in the nest of the dark-colored species. Wasmann, too ('99a), has observed a colony of *L. fuliginosus* appropriating the larvæ and pupæ of a neighboring colony of *Myrmica lævinodis*. I have repeatedly observed the same instinct in Mexican and Texan Ecitons ('01; *E. crassicorne*, *schmitti*, *pilosum*).[2] It is also probable that many cases

[1] This latter statement is disproved, at least so far as the American *sanguinea* is concerned, by the above-quoted observation of Forel.

[2] Although these ants often store the larvæ and pupæ in their nests for some time, they are probably never allowed to develop; but even if some of them

of synclerobiosis (especially those of *F. exsectoides* with *subsericea*) are due to a sporadic outcropping of this ancient instinct.[1] In view of the further facts that *sanguinea* can get on perfectly without auxiliaries, that it is the young colonies which usually contain the greatest number of slaves, and that the number of these is often highly variable in different colonies even in the same localities, we are certainly justified in demanding more stringent proof that *sanguinea* really robs for the sake of rearing slaves.[2] Laying most stress on the fact that the booty serves as food, — and of this Forel's observations contain sufficient evidence ('**74**, p. 258),[3] — we may regard the imaginal auxiliaries in the *sanguinea* nests as a *mere by-product*, as it were, of the colonial activities. The *sanguinea* often appropriate more food than they can devour, and the residuum merely adds workers to the colony, which are not harmful and may even be advantageous. This is evidently the interpretation intended by Darwin, who does not pretend to invoke the principle of natural selection in his genetic explanation of the *sanguinea* stage of dulosis, so that Wasmann has taken unnecessary pains to refute an imaginary argument. With

should hatch, the nomadic habits of the Ecitons and their poorly developed deportation instinct would prevent the formation of permanent mixed colonies, since the larvæ and pupæ which they kidnap belong to home-loving species.

[1] At Colebrook, Conn., I recently found three cases of synclerobiosis in addition to those enumerated in the second part of this paper: (1) a colony of *F. exsectoides* with *F. subsericea*, similar to the mixed colonies of these species observed by Forel and Schmitt; (2) *F. nitidiventris* with *F. rufa* var. *obscuripes* Forel; (3) *F. nitidiventris* with *F. rufa* var. *difficilis* Emery. All of these colonies were small, and in none of them could I find the queens of either of the consociating species.

[2] Wasmann believes ('**91**, p. 198) that in *sanguinea* the perception of the pupæ and the idea of their abduction are intimately connected by association with the idea of the auxiliaries to be bred from them, and he concludes: "Hieraus dürfte sich die Neigung der *sanguinea* zum Sklavenraub und zur Aufzucht fremder Hilfsameisen am leichtesten begreifen." This is one of the cases in which I am inclined to believe that Wasmann has greatly overestimated the power of association in ants. His statement, however, as he himself would probably admit, can hardly be regarded as proof of the point under discussion.

[3] "The *F. sanguinea* rarely rear all the cocoons of *F. pratensis* which they are given. Of these they often devour a great portion. One *sanguinea* formicary to which I gave a fabulous number of *F. pratensis* cocoons during the course of the summer failed to rear a single one. The same was true of several other formicaries to which I gave fewer cocoons."

F. sanguinea, however, there is already given the generalized condition required as a starting point for the action of natural selection and the development under its guidance of cases like Polyergus, as Darwin suggests. In Polyergus the predatory instincts have been developed to a highly specialized condition, while the domestic instincts have retrograded *pari passu* as a natural result of the survival of the prey, till the presence of slaves in the nest has become a *conditio sine quâ non* of existence. This correlation of instincts has involved the corresponding correlation of structure which we find so beautifully exhibited in Polyergus.[1] In the predatory instincts every slight variation in advance would be beneficial to the species, while slight retrogressions would not under the circumstances be disadvantageous. I cannot, therefore, agree with Wasmann when he says (**'91**, p. 247) : "Natural selection could only maintain and augment useful instinct variations : but the development of slavery up to the Polyergus-, Strongylognathus-, and Anergates-stage is beneficial neither to the masters nor the slaves — *ergo* natural selection cannot have produced the instincts of the slave-holding ants." As good an answer as I can conceive to an argument of this nature is a reference to the cases of extremely specialized parasitism like the Cestode and Sacculina, both of which are connected by tolerably complete series of intermediate forms with the more generalized, non-parasitic members of their respective phyla.

The symbiotic sequence suggested by Forel and Lubbock is objected to by Wasmann on fairly good grounds. It is by no means clear that the development has passed successively through the stages represented by these forms. Indeed, as Wasmann shows, the problem of symbiogenesis is much more complicated than it appeared when the above sequence was suggested. It now seems evident that several lines of development have proceeded independently from cases of plesiobiosis (and possibly also parabiosis), which constituted the necessary initial stages of symbiogenesis. Thus it is probable that cleptobiosis, xenobiosis, and dulosis represent at least three

[1] In accounting for this development of instincts and structures, it is, of course, necessary to regard the whole mixed colony as a single evolutionary unit.

discrete lines of development, the two former starting from conditions of plesiobiosis, the latter from the widespread instincts of ants to prey on the offspring of other Formicidæ. Other cases which obviously resemble true dulosis may have arisen from xenobiosis. This appears to be true of cases like *Leptothorax emersoni* and possibly also of the species of Strongylognathus and Tomognathus. On the other hand, the cases of colacobiosis may be conceived to have originated either from xenobiotic conditions like that of *L. emersoni* or from dulotic conditions like that of *Strongylognathus testaceus*. I cannot believe that Forel or Lubbock really intended their sequence as anything more than a rather general attempt in concrete language to account for the phylogenetic derivation of the remarkable cases of social parasitism (Anergates) from the simpler forms of mixed nests. It is therefore superfluous to waste many words for the sake of showing that the ants of the Forel-Lubbock series are not phylogenetically related. It is not only easier to sketch the phylogeny of the compound and mixed nests in bold outlines than to fill in the details, as Wasmann somewhat reproachfully suggests, but this is the only available method of procedure at the present time. Still even the attempt at detailed speculation in this direction scarcely merits our disapproval as it does Wasmann's, for free and open speculation is necessary to the advancement of a scientific subject, if only as furnishing the necessary incentives and guides to the attainment of profounder insight. Mere fact-culling is not and never can be science.

Another argument on which Wasmann lays some stress is drawn from the supposed immutability of instinct.[1] The instincts of *F. sanguinea* and Polyergus are regarded as identical both in Europe and America, and these instincts must therefore have remained unchanged for a very long period of time ('91, p. 249). "Huber's amazons of 1804 fought and

[1] It is unnecessary in this place to deal with the doctrine of the immutability of instinct so brilliantly advocated by Fabre ('79–'00). That it is quite untenable has been demonstrated by Dr. and Mrs. Peckham ('98), Whitman ('99), and others. It could, in fact, be demonstrated to be false from Fabre's own magnificent observations. The genus Leptothorax, considered below, furnishes additional evidence, if this were needed.

conquered exactly like Forel's amazons of 1870, and proved themselves to be quite as dependent on their slaves as their modern descendants; and there can be no doubt, that if Adam had studied and described the habits of the amazons, his account would agree very accurately with Huber's and Forel's." Similarly, Wasmann stresses the long-existing fixity of instinct in Formicoxenus and Leptothorax (p. 226). No issue can be taken with him on this point — but what phylogenist would not take it for granted? If structure can remain stable during æons of geological time, certainly instinct may also remain relatively unchanged. It is, however, equally true — and this point seems not to have been considered by Wasmann — that structure may undergo little change as compared with instinct. In support of this statement I would include in this place a series of facts which may have arrested the attention of the reader in the previous portions of this paper, *viz.*, *the remarkable differences of instinct exhibited by the species of the single genus Leptothorax.* Morphologically, this very large and widely distributed genus has been justly styled "homogeneous" by Forel ('74, p. 339), since the numerous species are closely related to one another and often separable only on rather trivial characters. Even the subgenera Dichothorax and Temnothorax are based on relatively slight differences. In their habits, on the other hand, the species of Leptothorax are singularly diverse. Many of the forms have no tendency to consort with ants of other species, but differ considerably in the stations which they inhabit. Some prefer to live under stones, others in moss, others under bark or in dead wood, and still others, like one of the Texan species, in cynipid galls, or, like our New England *L. longispinosus* Rog., in worm-eaten hickory nuts among the dead leaves under the trees. Many species, however, have a pronounced *penchant* for entering into more or less intimate symbiotic relations with other Formicidæ, as shown in the following conspectus:

1. The European *L. muscorum* often lives in plesiobiosis with *Formica rufa* (see pp. 519, 520).

2. A similar tendency is undoubtedly exhibited by our

American *L. canadensis* Provencher,[1] which I have had occasion to observe since the second part of this paper was written. June 21, I found at Cudahy, near Milwaukee, Wis., two nests of this Leptothorax compounded with a large nest of *Cremastogaster lineolata* Say in an old oak stump. The galleries of the Cremastogaster extended far into the dry rotten wood and contained numerous worker larvæ and pupæ. The two Leptothorax nests, which together scarcely contained more than sixty to seventy ants, were about twenty inches apart. Each was a simple chamber one-half to three-quarters of an inch in diameter excavated in the thick bark, and each communicated by means of a slender passage with the subcortical space, which was used as a common runway by the workers of both species. When the bark was stripped off, several of the Leptothorax were seen running on the surface of the wood and mingling with the Cremastogasters, which they closely resembled in coloration and sculpture, though differing in size, shape, and movement. The Leptothorax were very timid, and when touched with the fingers or tweezers, at once curled up and "feigned death," after the manner of Myrmecina. One of the nests contained several mature larvæ and pseudonymphs. These the workers and the single deälated queen were hastily removing to a place of safety. Rain began to fall soon after I had opened this interesting compound nest, and I was obliged to continue my observations on some living specimens of both the species hurriedly confined to a small vial. When the two species met, as they often did in these narrow quarters, the Cremastogaster stroked the Leptothorax with its antennæ. On such occasions the latter at once crouched motionless and folded its antennæ along the sides of its head. Then sometimes the Cremastogaster would stand over the little ant and lick its rugose head and thorax; at other times it would pass on without bestowing these attentions on the Leptothorax, which at once sprang to its feet and ran away. This performance was repeated so often during the remainder of the day that there could be no doubt

[1] According to Emery ('**94**, p. 318) this ant is perhaps only a subspecies of the European *L. acervorum*.

concerning the friendly relations of the two species. By the following morning the Leptothorax and most of the Cremastogasters were either dead or dying, having been suffocated by the pungent exhalations of the latter species. Thus the little I could observe of the relations of the two species resembled those which I have recorded for *L. emersoni* and *Myrmica brevinodis* — only reversed, the *L. canadensis* behaving like the Myrmica, while the Cremastogaster behaved somewhat like *L. emersoni*.[1]

3. *L. pergandei* lives, probably as a guest, in the nests of *Monomorium minutum* var. *minimum* (see p. 539).

4. The single colony of the Mexican *L. petiolatus* which I have seen was living in parabiosis with species of Cryptocerus and Cremastogaster (see p. 527).

5. *L. tuberum* var. *unifasciatus* lives with the European *Formicoxenus ravouxi*, the relations between the species being, perhaps, the same as those which obtain between *Formica rufa* and *Formicoxenus nitidulus* (see p. 538).

6. *L. muscorum*, *L. acervorum*, and *L. tuberum* live as slaves or auxiliaries with the European *Tomognathus sublævis* (see pp. 70, 71).

7. *L. curvispinosus* probably performs the same rôle in the nests of *T. americanus* (see p. 715).

8. *L. tuberum* has been found associated with *Strongylognathus testaceus*. Here, too, the Leptothorax probably acts as the slave of the dulotic species (see p. 710).

9. *L. emersoni* lives with *Myrmica brevinodis* as described in the first part of this paper. The compound nest resembles that of *L. canadensis* with Cremastogaster and of *Formicoxenus nitidulus* with *Formica rufa*, but the relations between the two species of ants are like those existing in mixed nests. In one sense *L. emersoni* is the dominant species and the huge Myrmicas are its auxiliaries, or slaves; in another sense the

[1] At Colebrook, Conn., July 22, I again encountered *L. canadensis*. In this instance the workers were running about on some stones which covered a very extensive nest of *Formica rufa* var *difficilis Em*. The Leptothorax nest, which was probably compounded with that of the *rufa*, was not found. This fact is of some interest in connection with the remarks on *L. muscorum*, recorded at p. 519.

Leptothorax is a guest or social parasite resembling Anergates, though still retaining intact its own household and its domestic instincts. *L. emersoni* may therefore be said to combine in itself the instincts of ants belonging to several categories of mixed and compound nests.

The range of habits clearly indicated in this brief survey of our very fragmentary knowledge of Leptothorax species is still further enlarged if we include the genera Tomognathus and Formicoxenus, both of which are closely allied to Leptothorax. In fact, Tomognathus is indistinguishable from Leptothorax in the male sex and larval stages (Adlerz, '96). That the three myrmicine genera under consideration must have had a common origin is evident from their morphology. Nevertheless the habits of the various species are so diverse as to represent all the forms of social symbiosis except colacobiosis of the extreme type found in Anergates. It is evident, furthermore, that the ants of these genera must have originally possessed certain traits which made it especially easy for them to enter into symbiotic relations with other species of Formicidæ. I believe that we may still recognize in many of the species of Leptothorax several of these traits, such as the following:

1. The genus has a very wide geographical distribution, a prerequisite to the establishment of such numerous and varied relations with other ants.

2. The species are all of small size. This must undoubtedly facilitate their association with other ants.

3. The colonies consist of a relatively small number of individuals. This, too, must greatly facilitate life as guests or parasites in the nests of other ants.

4. Most of the species are rather timid, or at any rate not belligerent. They are, therefore, of a more adaptable temperament than many other ants even of the same size (*e.g.*, *Tetramorium cæspitum*). Forel ('74, pp. 339, 340) has shown that *L. tubero-affinis* will rear pupæ of *L. nylanderi* and even of *Tetramorium cæspitum* and live on good terms with the imagines when they hatch.

5. There is no very sharp differentiation in habits between the queens and workers of Leptothorax. This, too, should

facilitate symbiosis. The queens, as I have shown in the case of *L. emersoni*, may retain the excavating instinct and the instincts which relate to the care of the larvæ. Wasmann ('**91**, p. 219, footnote) saw the queen of *L. tuberum* var. *nigriceps* removing the larvæ and pupæ when the nest was disturbed, and I have recorded above a similar observation on *L. canadense*. More recently I have seen both the winged and deälated queens in a nest of *L. longispinosus* carrying away the larvæ quite as busily as the workers. It is as Forel says ('**74**, p. 339): "Les ♀ vivent presque comme les ☿; elles sont seulement moins aptes au travail."

6. The similarity in instinct between the queens and workers of Leptothorax finds its physical expression in the frequent occurrence of intermediate, or ergatogynous, forms. So-called microgynic individuals, or winged queens no larger than the workers, have been frequently observed by Forel ('**74**, p. 341) and Wasmann ('**95**, p. 618) in *L. acervorum*. Those observed by the latter author also showed color transitions between the normal queens and workers. Adlerz ('**86**, p. 77) found microgynic individuals in *L. acervorum*, *muscorum*, and *tuberum*. Still other ergatogynous forms, which may be called ergatoid queens, are represented by the large ocelligerous workers of *L. emersoni* described and figured in the first part of this paper (pp. 434, 436). These individuals bear a striking and suggestive resemblance to the ergatoid queens of *Tomognathus sublævis* described and figured by Alderz. Wasmann ('**95**, p. 619) also records the occurrence of what he calls "ergatogyne Mischformen," or individuals completely transitional between the queens and workers, in colonies of *L. acervorum* and *Formicoxenus nitidulus*.

It is possible to draw still further inferences from the heterogeneous instincts exhibited by the genus Leptothorax and its allies. Viewed as a whole, these different symbiotic relations cannot be said to bear the ear-marks of internal developmental causes operating in a perfectly determinate manner. Indeed, appearances are quite otherwise and seem rather to point to indeterminate variations which have been and are still in process of being seized on and fixed by natural selection. It

must also be admitted that the same appearance is presented by the whole complex of conditions in compound and mixed nests, but the demonstration is more cogent when it can be shown that we have relations as different as those of dominant species (*L. emersoni*) and slaves (*L. acervorum*) not only in the same genus but among closely allied forms. *This fact also suggests that the instincts of the same species may be so generalized as to enable it to function like man, either as a slave or master, according to the circumstances.*

Although these considerations may seem to lack precision they certainly show that we cannot dogmatize on the inadequacy of natural selection from a study of a few highly specialized ants like *F. sanguinea* and *Polyergus rufescens*. The complicated phylogeny of the mixed nests can only be established after a patient study of genera like Leptothorax and Tomognathus. Another even more neglected group of small ants which promises to throw some light on this subject comprises the species of Monomorium with the allied genus Xenomyrmex. At present so very little is known concerning the habits of these genera that it must suffice merely to call attention to them in this connection.

It is necessary in conclusion to consider very briefly the psychological problems suggested by the phenomena of social symbiosis, since, as above stated, the cases of dulosis have led authors to postulate unusual mental powers in ants. The accounts of sane and critical workers like Forel have been distorted by the "popularizer," till one almost believes that the *ante-bellum* Southerner might have learned many things in the management of his slaves from a conscientious observance of Proverbs vi. 6. Wasmann in his numerous writings ('**91**, '**97**, '**99**, '**99b**, etc.) has undoubtedly done much, at least in Germany, towards the exposure of this pseudo-psychology and a more rational conception of ant behavior. His long familiarity with these animals and their guests has given him a singularly lucid insight into their activities. My own more limited observations on our North American species lead me to agree with him so far as the facts are concerned and many of the inferences which he has drawn from them. I am constrained to say, however,

that I cannot adopt either his psychological definitions or his psychogenetic reservations.

Wasmann seems to me unduly to expand the conception of instinct in one direction, while circumscribing it rather too narrowly in another. It is true that he distinguishes instinct *sensu stricto*, the equivalent of the term as employed by many comparative psychologists to designate the purposeful, automatic, or stereotyped hereditary activities which are performed prior to all experience and without awareness of their object, and instinct *sensu lato*, which embraces also the activities depending on the sense-experience of the individual, and all that this implies, — adaptation and choice, associative memory, etc., — activities which have come to be very generally designated as "intelligent." But he does not appear to regard these differences as sufficiently important to merit sharp distinction. Indeed, he even attempts ('99, p. 12 *et seq.*) to show that the presence of an element of experience in the associative process of an animal is not of sufficient moment to merit distinction from purely hereditary associations. This, I believe, few psychologists will admit. The detection of such a difference, however difficult it may be in practice, is surely not beyond the possibility of carefully devised experimentation and induction. And theoretically the two kinds of activity should certainly be distinguished and separately designated. Wasmann traces the non-stereotyped activities depending on choice to a "sinnliches Erkenntniss- und Begehrungsvermögen," which he regards as being the distinguishing trait of instinct. Thus he comes to include under instinct both the instinct and intelligence of other authors. I believe with Emery ('93, '98) and Bethe ('98) that Wasmann has overshot the mark and attempted to include too much in his conception of instinct. I should continue, therefore, to emphasize the difference between activities which are compelled by inherited mechanism and those which imply choice on the part of the individual organism. For the latter the term "intelligence" has been so very generally used that it seems both hopeless and idle to try to restrict it, as Wasmann so emphatically desires, to the ratiocinative process in its clearest manifestations.

That instinct activities and activities implying choice should not be included under the same name is also evident from the difficulties which we experience when we attempt to show how the former could pass over into the latter; although the ingenious hypothesis of Spencer, James, Morgan, and Whitman ('99, p. 333 *et seq.*) may indicate where we are to seek for this transition, which these authors find in the progressive complication and mutual interference of instincts. Such conditions, it is claimed, must lead to a diminution in the automaticity of instinct and the supervention of a state of hesitancy and choice on the part of the organism.

While on the one hand, as above stated, Wasmann improperly expands the conception of instinct by including in it also the simpler manifestations of intelligence, he narrows it in another direction when he attempts to distinguish rather too sharply between reflex action and instinct. His criterion that reflex action depends essentially on the function of subordinate ganglia, whereas instinct depends on the activity of a brain, or sensorium, can only be maintained if the conception of instinct is restricted to the Metazoa and understood as including intelligence (*sensu auctorum*). But with the rejection of this definition of instinct we must also reject such a distinction between reflex action and instinct.

It may be said in this connection that the attempts of others to distinguish between instinct and reflex action are almost equally unsatisfactory. This is true, *e.g.*, of the distinction emphasized by Romanes, when he says ('95, p. 12): "I endeavor to draw as sharply as possible the line which *in theory* should be taken to separate instinctive from reflex action; and this line, as I have already said, is constituted by the boundary of non-mental or unconscious adjustment, with adjustment in which there is concerned consciousness or mind." It is well that Romanes has stamped his distinction as a theoretical one, for its application in comparative psychology is obviously impracticable, since it must fluctuate with our opinions concerning the presence or absence of consciousness in different animals. It is not at all certain that consciousness is present in the cases of pure instinct; or, if present, it may exist as a

mere epiphenomenon as Morgan explains ('00, p. 208) : "An organism — if such exists — in which all the activities are throughout life purely automatic and purely instinctive, might indeed be conscious, but its consciousness would be of no practical value ; for all the activities being, *ex hypothesi*, automatic, there would be no conscious guidance or control. Consciousness might be present as a spectator of the activities, but it would be a mere spectator without power of guidance, since, in so far as guided by intelligence, activities cease to be instinctive. It should be clearly grasped that, in so far as an activity is guided by individual control towards more complete accuracy, just so far does it cease to be instinctive, as the word is here used, and become intelligent. And when an instinct is, as so often is the case, modified and adapted to meet new circumstances, the modification and adaptation is no part of the instinct as such, but is due to intelligent control.

"I repeat, then, that in instinct as such consciousness is an epiphenomenon or adjunct. But this does not, of course, imply that it is absent. Only in so far as consciousness accompanies the performance of instinctive activities can intelligence get a hold on them for the purpose of control and guidance. The performance of automatic activities affords to consciousness data, which form a foundation upon which the psychical structure reared by intelligence is based."

Finally, the distinction noted by Spencer, Morgan, and others that reflex action is "localized response involving a particular organ or a definite group of muscles initiated by a more or less specialized external stimulus," whereas "instinctive activity is a response of the organism as a whole, involving the coöperation of several organs and many groups of muscles," implies only a difference in degree as Marshall ('98, p. 100 *et seq.*) and Loeb ('00, p. 77) have pointed out ; for when we extend our view to simple as well as complex organisms, and forget for the moment the staple experiments of neuro-muscular physiology, we must agree with James when he says ('90, p. 384) that the "actions we call instinctive all conform to the general reflex type," and with Marshall ('98, p. 100) when he says : "All

instincts appear as modes of that simplest of all forms of activity, the reaction of a living cell to the stimulus received from its environment." And we are led to conclude with Loeb ('00, p. 177) that "the discrimination between reflex and instinctive actions is chiefly conventional." The work of this last author, above all others, is of great value in freeing us from some of the traditional misconceptions of instinct. He has succeeded in tracing a number of instincts to simple tropisms (or taxes) and has shown good reasons for maintaining that many of the more complicated instincts are only catenary reflexes (Kettenreflexe). These, however, have not yet been sufficiently analyzed.

Loeb's conception is also fruitful in another direction, for as Mach says ('00, p. 64) it throws light on the relations between development and instinct. Numerous "instincts" of ants, such as their reactions to moisture, heat, light, and contact, are evidently simple reflexes and may, I believe, be treated as cases of hygro-, thermo-, helio-, and thigmotaxis. The first and last of these reactions are especially striking. Similarly the olfactory reactions, which are such an extremely important factor in the lives of ants, are probably not essentially different from the chemotactic reactions of simpler organisms. The consociation of ants in mixed and compound nests is undoubtedly dependent to a very considerable extent on olfactory reactions. The young auxiliaries that hatch from stolen pupæ are at once adopted in the mixed nests because they have acquired the nest odor of the dominant species. Moreover, the fact that these intimate relations are established only between ants of rather close taxonomic affinities is probably due to their having very similar odoriferous secretions to begin with. The animosity of ants seems to be at once excited by species which emit peculiar or unfamiliar odors. While I accept Loeb's conception as simplifying to a considerable extent the problem of instinct, I cannot suppose with Bethe ('98, '00) that the behavior of ants and bees is entirely of a reflex nature; I can only indorse Wasmann's ('99b) and Forel's ('00–'01) comments on this author's extreme views.

Wasmann ('91, p. 179 *et seq.*) has shown in detail why it is

quite unnecessary to assume the existence of anything beyond instinct and simple intelligence in the ants which form compound and mixed nests. I should even be inclined to place a more moderate estimate than Wasmann on the psychical endowments of these animals. The manifestations of intelligence are very feeble, as any observer who tries to free himself from anthropomorphism will surely find. There are distinct traces of associations with indications of some permanence of these associations, or what might be called animal memory as restricted in its meaning by Thorndike ('**98**, pp. 98, 99). Imitation is clearly manifested, but in a form which does not necessarily imply the existence of consciousness. There is a certain ability to profit by experience, and considerable power of adaptation to new circumstances, both remarkably developed as compared with these powers in other insects. There is evidence of choice and of that which it necessarily presupposes, *viz.*, will, but there are no evidences of anything resembling abstract thought, cognition, or ratiocination as manifested in man. Nor are there the slightest grounds for postulating the existence of these powers, which would be a hindrance rather than a help in the activities of ants under existing conditions.

Having arrived at the same conclusion as Wasmann that there are no evidences of ratiocination in ants we have reached the limits of our brief inquiry. This conclusion, however, even if it be extended so as to exclude all animals except man from a participation in this faculty, does not imply the admission of a qualitative difference between the human and animal psyche, as understood by Wasmann. Surely the sciences of comparative physiology, anatomy, and embryology, not to mention paleontology, distribution, and taxonomy, must have been cultivated to little purpose during the nineteenth century if we are to rest satisfied with the scholastic definition of ratiocination as an adequate and final verity. And surely no one who is conversant with modern biological science will accept the views that the power of abstract, ratiocinative thought, which is absent in infants and young children, scarcely developed in savages and highly developed and generally manifested only in the minority of civilized men, has miraculously sprung into

existence in full panoply like the daughter of Jove. Such conceptions recall the rhetorical figure which Houzeau ('72, Vol. II, p. 264) aptly uses in his discussion of this same matter: "The spark," he says, "which we draw from a rod of wax is analogous to that from the Leyden jar and we attribute it to electricity. Had we from the very first sought to liken it to the thunderbolt, the difference of proportions, the quantitative inequality might have been such that we should have been scandalized by the comparison." But we need not dwell on mere opinions respecting the status of ratiocination in the animal kingdom. That the task of tracing reason to more generalized and primitive psychic processes is not impossible is shown by Binet's recent investigations ('01), the gist of which is included in the following quotation (p. 159): "There is no decided difference between perception and logical reasoning; the two operations are both reasonings, transitions from the known to the unknown. The analogy is so close that we were able to compare perception with formal reasoning, and to show that perception contains all the essential elements of a peripatetic syllogism (see p. 88). In short, perception and logical reasoning are only the two extremes of a long series of phenomena, and when we place ourselves in the middle of the series we find inferences which belong to both at the same time (see p. 70). Further, we have shown that a kind of filial relationship exists between perception and the reasonings of conscious logic. Thus when we make systematized anæsthesia, which has been developed in a patient relatively to a certain person, gradually disappear, the thing which appears first of all is the perception of the person as species; and it is only afterwards, by a kind of ascending evolution, that the recognition of the person as individual takes place; now, we know that recognition is a complex operation which touches closely upon reasoning properly so called. All these reasons lead to the belief that perceptive reasoning and logical reasoning imply the same mechanism (see p. 77)." A somewhat similar conclusion respecting the derivation of ratiocination is reached by Wundt ('01, pp. 342, 395).

However doubtful we may be of the complete success of attempts like that of Binet, we may be confident, nevertheless,

that they contain the germs of promise, for the consensus of the biological sciences leads us at last to one point of view: "We are prepared," as Mach says ('98, p. 235), "to regard ourselves and every one of our ideas as a product and a subject of universal evolution; and in this way we shall advance sturdily and unimpeded along the paths which the future will throw open to us."

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NOTES ON LIVING NAUTILUS.

BASHFORD DEAN.

During a recent visit to Manila I learned from Commissioner Dean C. Worcester that Nautilus, a form which one usually associates with remote and cannibal islands, could be collected quite readily in the straits between the islands of Negros and Cebu. This locality was accessible, and a short stay there, I was told, would afford one an opportunity of examining this, the only living picture of orthoceratids and ammonites, to say nothing of its greater interest as the probable key to the puzzles of cephalopod descent. So it came about that I visited Negros. Thanks to the kindness of Professor Worcester, the trip itself proved a zoölogical excursion *de luxe*, for he secured for me the services of his long-time guide, the taxidermist Mateo Francisco, and he put us in charge of his good friend, Don José Bocanegra, whose large sugar estate is near the town of Bais. It was during this trip that the following notes and sketches were outlined. They have been allowed to stand practically as jotted down, as first impressions, — with my apologies, and a dedication, if they are worth one, to the student of Nautilus, my good friend and former colleague in Columbia University, Dr. Arthur Willey.

Nautilus is doubtless common throughout the waters of the southern Philippines.[1] It can, however, be obtained so readily in the region of southern Negros that such a station, if only because of its accessibility, deserves to become a classic one. The reason why a deep-water form like Nautilus can be secured with little difficulty here is a simple one: it is a regular by-product, so to speak, of the traps of the fishermen. Its

[1] I note, in passing, that dead shells of Nautilus occur not uncommonly as far north as Japan. One was picked up a few years ago near the laboratory at Misaki (lat. 35° 10′ N.).

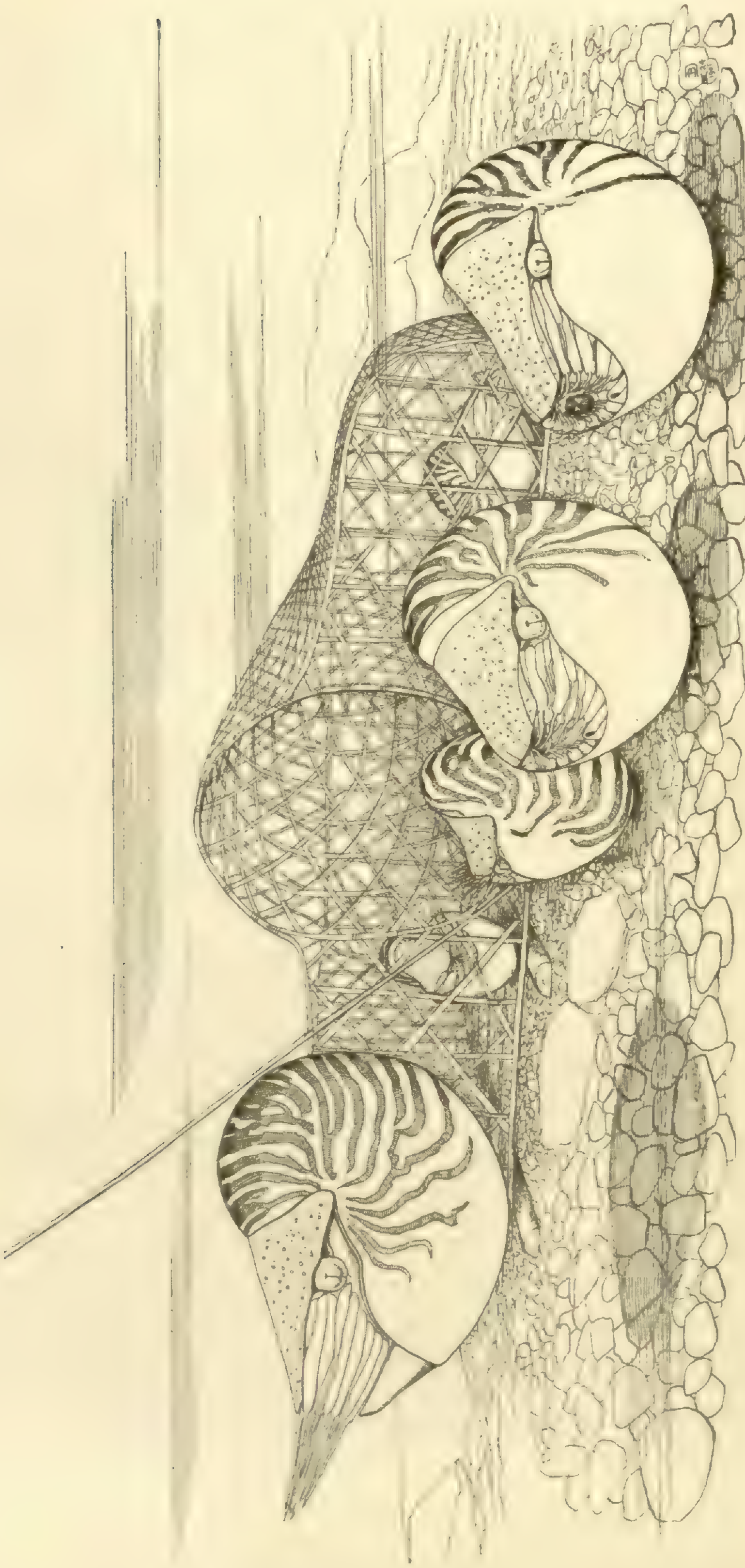


Fig. 1. — Sketch illustrating living Nautilus. In the background the Philippine fish-trap in which they are taken.

flesh is, indeed, eaten, but it is little esteemed. The shells have hitherto found little market; locally they are used as drinking cups, or flower vases, and are sometimes cut into roughly shaped spoons. But they are now bought extensively by Chinese shopkeepers, and at such good prices that there will probably be a goodly Nautilus fishery before long. The Chinese, I was told, export the shells to China, where they are used as material for button-making.

The best catches of Nautilus are made in deep water, that is, according to the estimates of the fishermen, at a depth of from 250 to 400 braças (= about 450–700 meters). I notice, however, that in the Spanish charts the maximum depth recorded is 200 meters, and it is probable accordingly that either the fishermen make extraordinary allowance for the sag of their line, or that the measurement given on the chart represents the maximum sounding limit of the Coast Survey steamer. As the water shallows, Nautilus becomes less abundant: in water of 100 meters it is still taken, although in small numbers. A single specimen, as Señor Romero informed me while at Bais, was collected in that bay by the native divers while gathering pearl oysters. There can, I believe, be little doubt of this instance, for my informant is well acquainted with Nautilus, and states that the animal was brought to him living. It was obtained in water less than 4 m. in depth.

The most favorable station thus far discovered is, as Professor Worcester stated, near the small fishing village Manjuyod, about six miles distant from Bais. This and other localities where I learned that Nautilus is taken are indicated in the accompanying outline map (Fig. 2). That it is taken off the villages of Cebu, Malaboyoc, Ginatilan, and Sambuan, I know only from hearsay. I was told that a Chinese shopkeeper made a tour of these places and collected 3000 shells; and he reported that the fishing was done not far from shore. In the locality indicated, near the pueblo of San Juan on the southern coast of Siquijor, Nautilus is taken in relatively shallow water, 100 m. and less; here, however, its abundance is inconstant. In this neighborhood I picked up a shell 3 cm. in diameter.

Season of the year has an important bearing upon collecting. Spring and early summer are the most favorable, probably because the water is quiet in the absence of the northern monsoon. June is generally stated to be the month in which

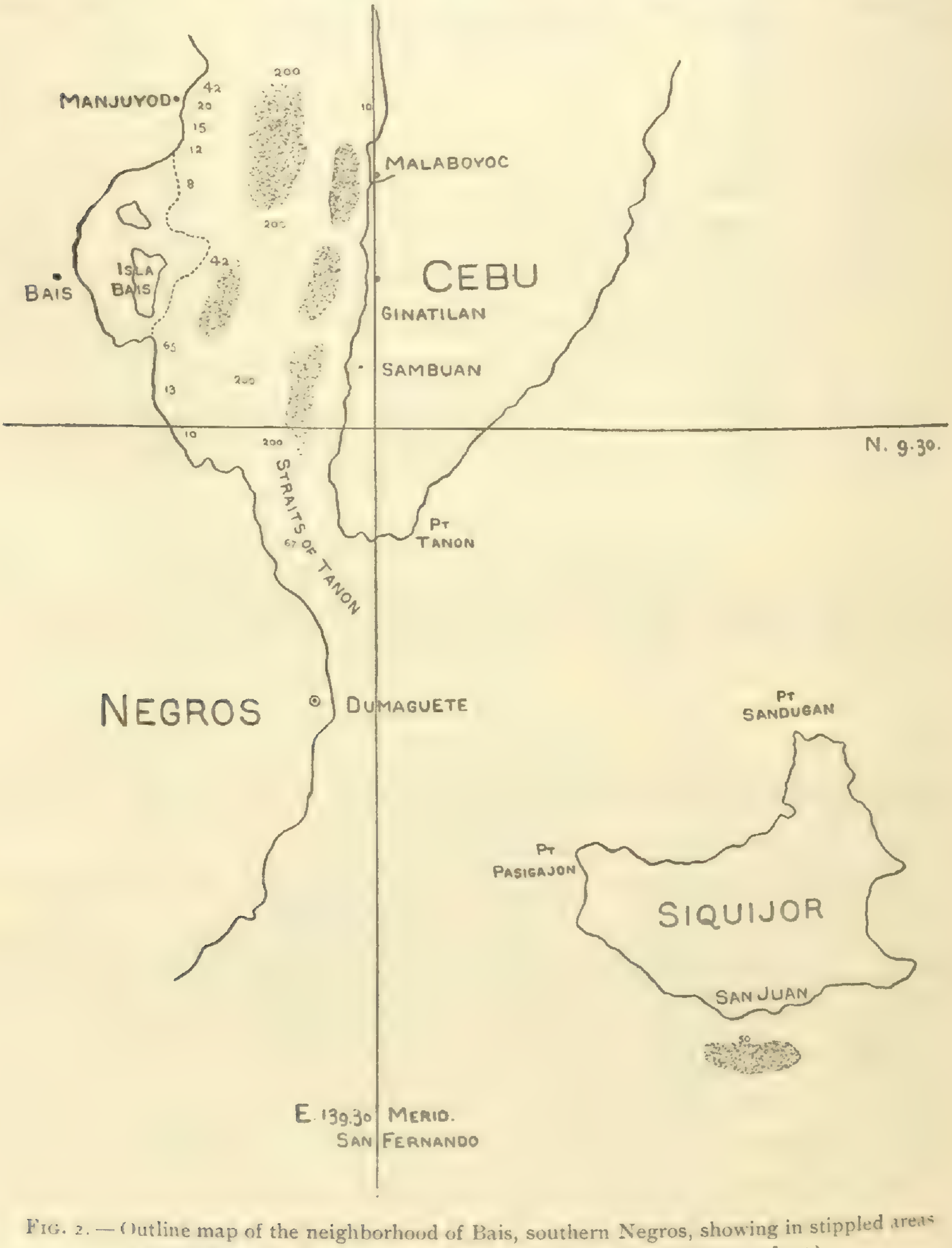


FIG. 2. — Outline map of the neighborhood of Bais, southern Negros, showing in stippled areas some of the fishing grounds for Nautilus. (After Spanish coast chart.)

the largest catches are made, as many as twenty shells having been taken in a single basket. The least favorable season is winter, for the wind sweeps down the straits between Negros and Cebu, raising a sea which soon swamps the small prahus of

the fishermen. It happened, therefore, that at the time of my visit, in January and February, I was able to get but few specimens.

The fishing, as has already been stated, is carried on by means of a fish-trap, a sketch of which is given in Fig. 3. It is a cage-like, flattened affair, about six feet in length, constructed of strips of bamboo woven in coarse mesh. At one end there is a funnel-shaped insinking through which the animals gain entrance. The funnel operates somewhat on the plan of the mouth of a rat live-trap, the animal pushing through it, not indeed at the pointed end, but on one side (the median ventral line, to borrow a phrase). Intercrossing strips then

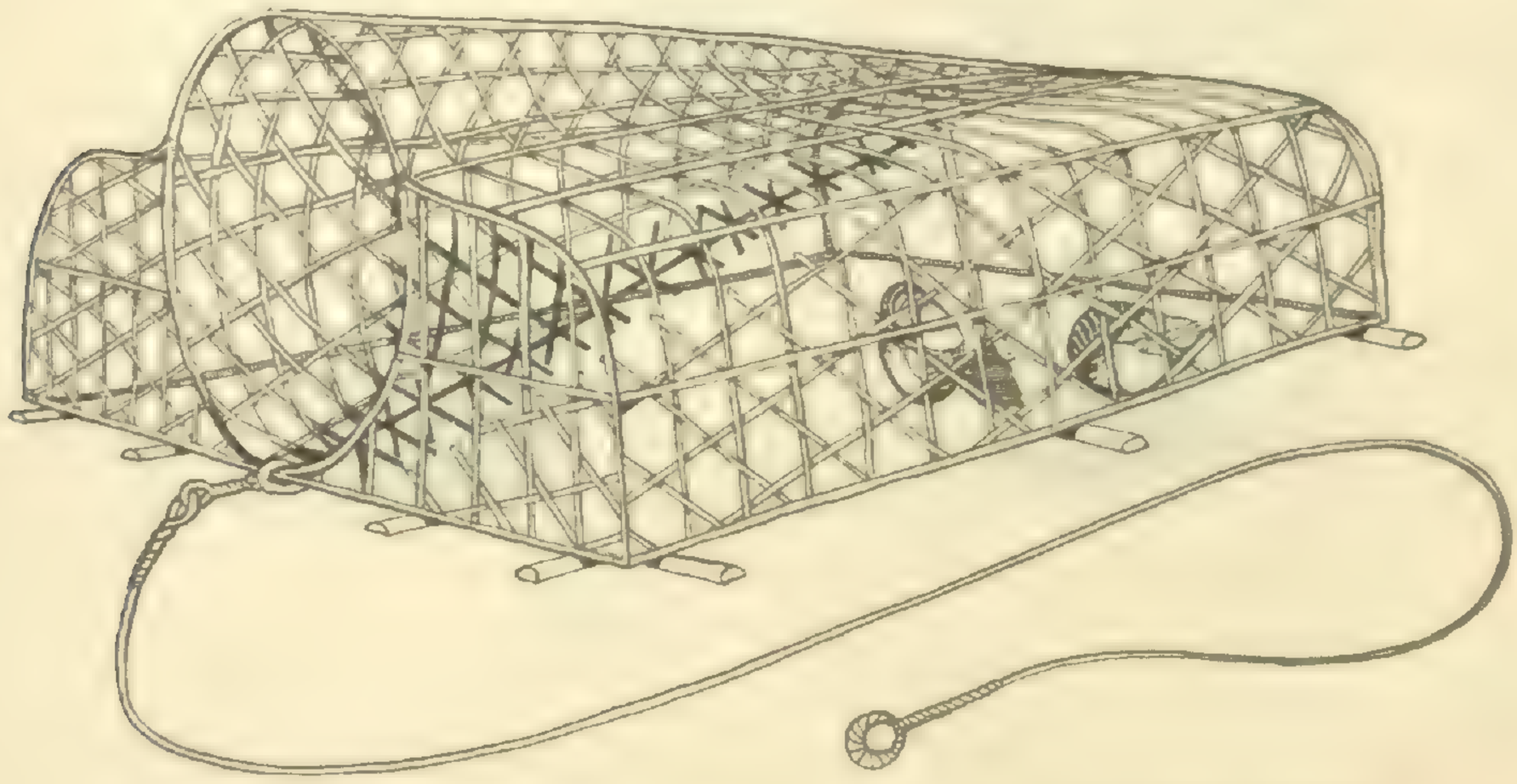


FIG. 3.—The Negros fish-cage, or "bo-bo," in which Nautilus is taken.

close elastically and prevent egress. The cage stands upon stout strips of bamboo, to which weights are usually attached. Bait is hung from the roof supports at various points. This consists of whole fowls, viscera or joints of kid, or the remains of dogs or cats when the latter attractions can be found. Freshness of bait is not regarded as a *sine qua non*. The cage "bo-bo," as it is called in Viscaya, is attached, in the way shown in the figure, by a strip of rattan, to the main line, also of rattan, which connects it with the float. The latter consists usually of several joints of bamboo. As to the method of fishing, it appears that the bo-bo is put down at a favorable opportunity, and is allowed to remain for several days, often for a week or longer. At San Juan I found that it was customary to examine the cages on stated days, weekly or

bi-weekly ; at Manjuyod, on the other hand, visits to the cages are made at irregular intervals. The bait is then renewed, the captured fish removed, — this through a trap-door in the bottom, — and the apparatus sunk again to the bottom.

In the accompanying cut (Fig. 1) I have attempted to represent a bo-bo in position, with Nautilus in and around it. This, I believe, gives a moderately accurate idea of some of the positions assumed by the animals. Several are represented, partly

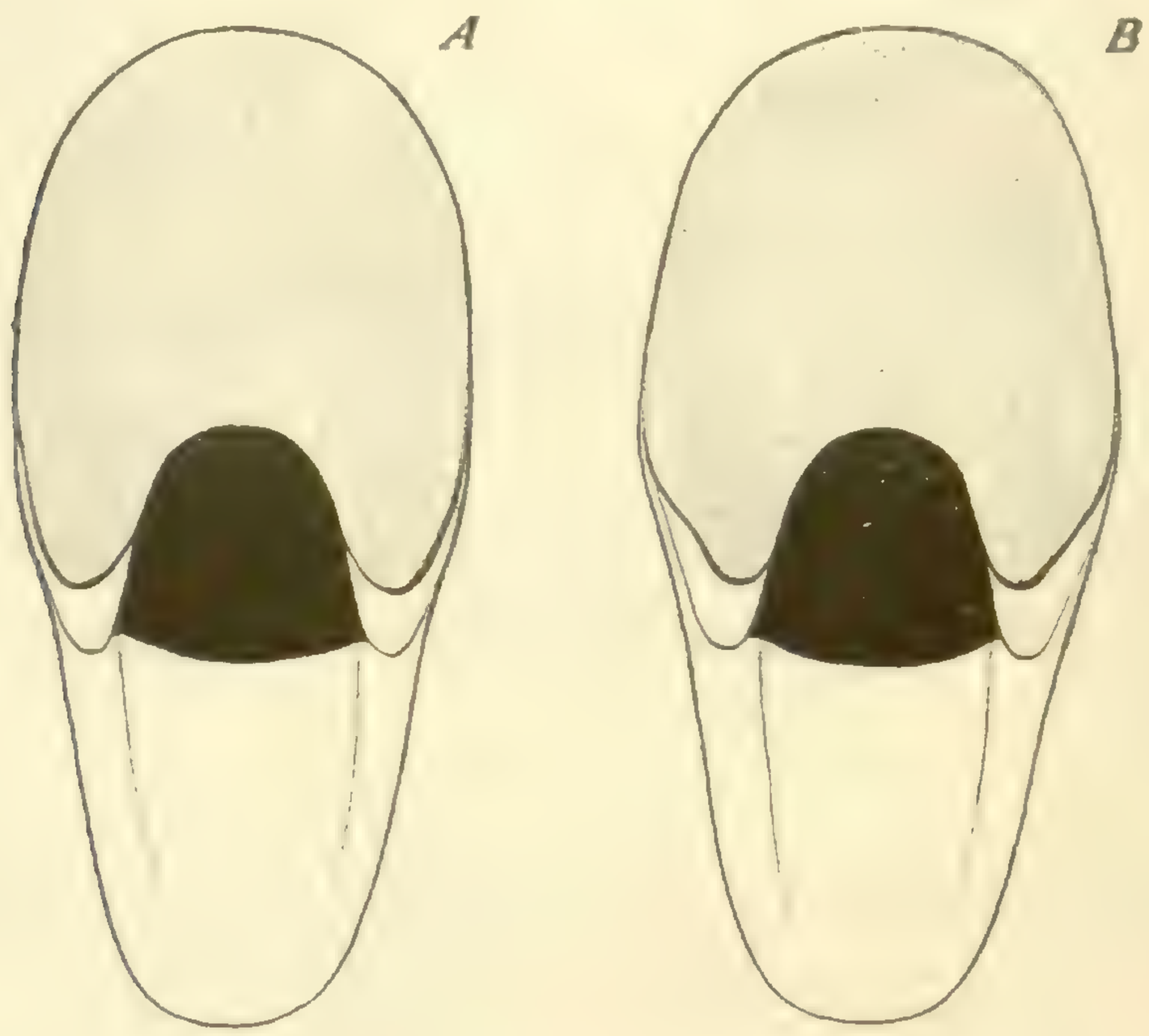


Fig. 4, *A* and *B*. — Diagrams of shells showing in stippled areas the oral apertures of male (*A*) and female (*B*) Nautilus.

retracted, in a position of rest, and one of them, attracted by the bait, is shown swimming rapidly near the bottom somewhat in the direction of the cage. The degree of shadow is, of course, hypothetical, and it is doubtful whether the bottom is as free from other living forms as I have indicated.

The Shell. — In examining fresh specimens I noticed that there appeared to be sexual differences in the shells. That of the female was wider at the sides of the oval aperture and here showed a somewhat angular contour. This peculiarity I have expressed in the accompanying Fig. 4, *B*, and it may be contrasted with the condition of the shell of a male shown in the

same figure, *A*. This difference was clear in the case of the six specimens I examined; but I later found that there must be considerable variation, for in looking over the shells obtained at Manjuyod I was unable to distinguish those of the females from those of the males in as many instances as three out of ten.[1]

Another character of the shell is the great number of irregular growth lines which they often present (Fig. 5). These lines show frequently, as in the figure at *, an undulation of a somewhat regular pattern, reminding one of the markings

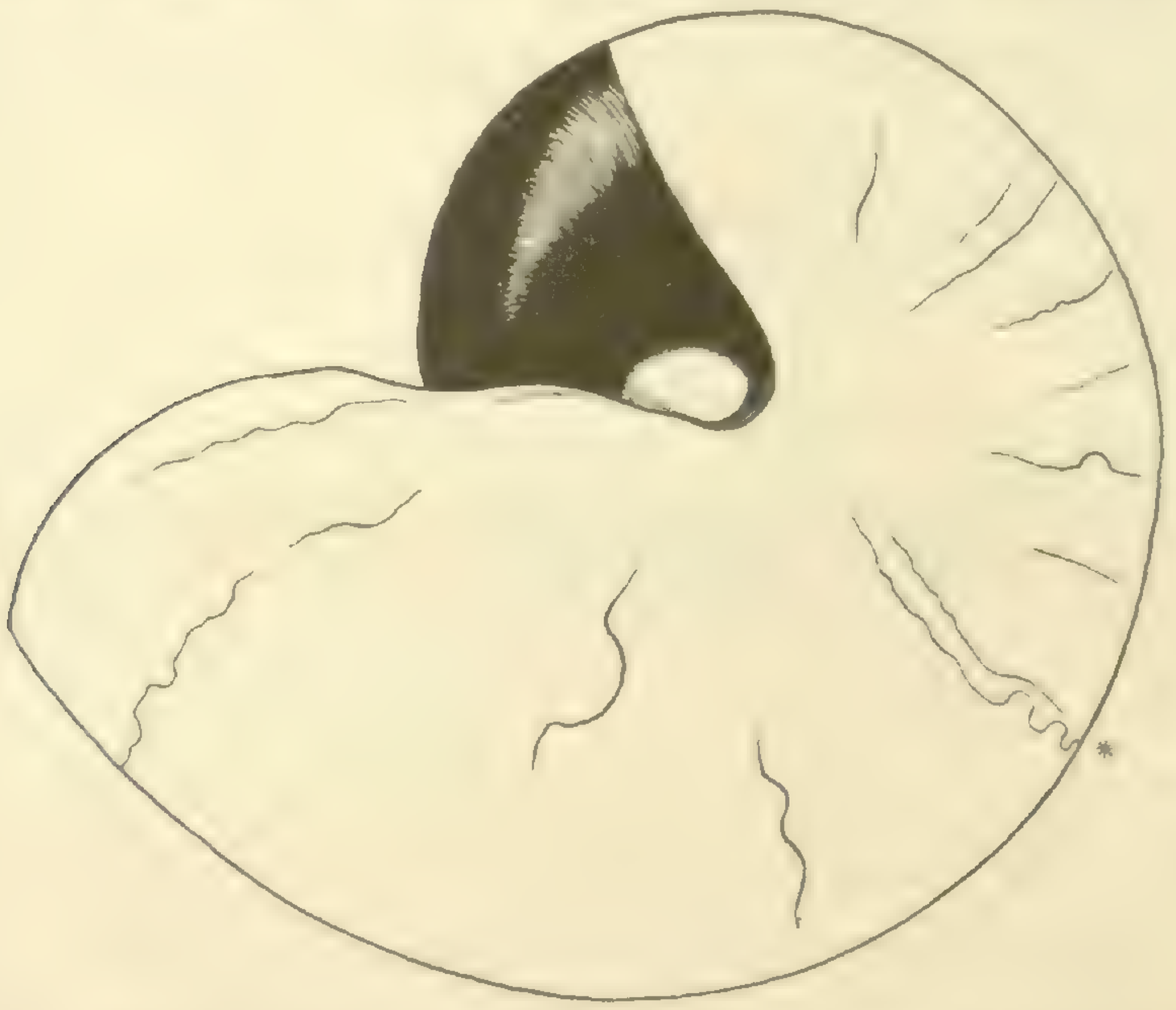


FIG. 5. — Shell of Nautilus. Outline sketch showing undulatory lines of growth.

formed at the septal rims in Ceratite or Goniatite. Doubtless this peculiarity in recent shells has already been commented upon, and the point made that the irregular growth lines cannot be directly related to those of the fossil forms, since they are not connected with the formation of septa, several being sometimes found on the wall of a single chamber. They are interesting, however, I suggest, as representing a tendency during special periods of shell-forming activity, perhaps after

[1] I find that Willey gives (1895, *Nat. Sci.*, p. 412) a similar note, stating that "in most adults the shell can readily be identified as belonging to male or female, but often this identification is very difficult, and in young shells impossible." He figures extremes of difference.

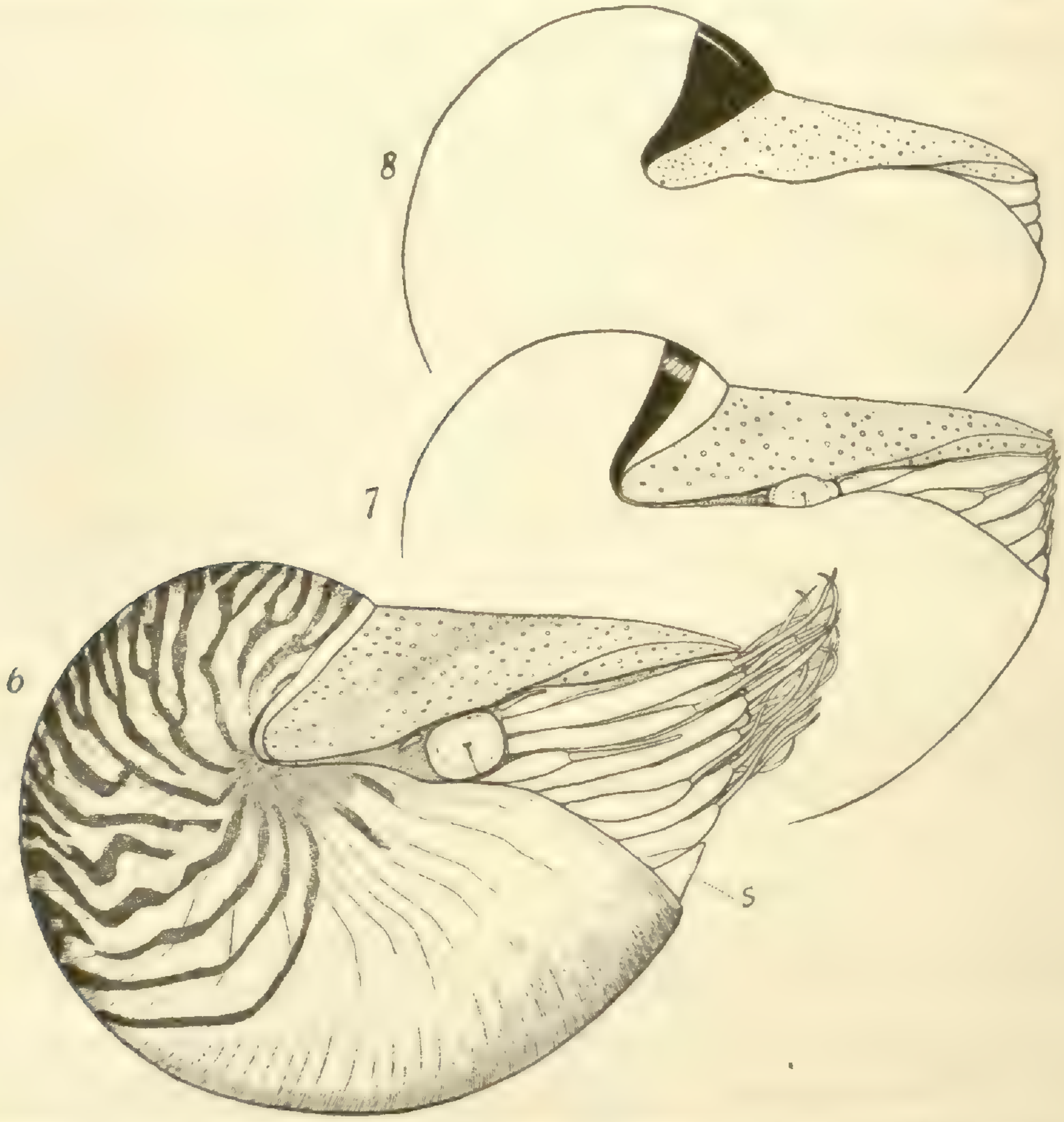
some unusual shock has been given to the free rim of the shell, for the mantle to contract in crenulate lines, a tendency which during the descent of the tetrabranchs may well have been seized upon by selection and made of use in the formation of the specialized margins of the septa. And from this standpoint the recent markings may be regarded as related to the curiously expressed lines on the ancient shells. They seem of entirely too regular a character, as close examination shows, to be interpreted merely as lines marking the repair of the free lip of the shell. Such lines of repair do, indeed, occur and are common, for the shell-lip is delicate and often apt to be injured in an animal with the evident habits of nautilus. I have in mind one instance when the shell had been repaired, after the lip had been crushed badly; in this case the main fracture passed backward from the rim of the lip to a distance of 4.5 cm.

General Appearance of the Living Animal. — The first glimpse at a living specimen showed it at the bottom of the vessel in which it had been brought, its position upright somewhat as shown in the present Fig. 6. If the vessel is sufficiently large the animal is usually found with its back (*i.e.*, its aboral pole, so to speak) pushed as far as possible into a corner. And if several specimens are thus confined they will often be found to have backed away from one another as far as possible. They remained thus almost motionless sometimes for hours; at other times they will exhibit active movements and subside quite suddenly. The color of the animal one gets little idea of from preserved specimens. The general color of the exposed parts, hood excepted, is white, clean, opaque, almost the same tint, in fact, as the body of the shell. The latter was in every case I observed brilliantly clean. The face of Nautilus, then, is white, as is also the dorsal fold of the mantle, which rises into sight within the concave hinder rim of the hood and covers when extended the jet-black portion of the coil of the shell. The dorsal surface of the hood, as one would infer from preserved specimens, is of a brownish color. Looking at this surface for the first time in a living specimen, one is given the impression that it has been spattered with burnt umber, raw

sienna, and yellow ochre, and that the pigment has then been carelessly wiped away, leaving the warty prominences in white relief. Nowhere are observed the characteristic chromatophores of the dibranch. The only pigmentation which may further be noted is on and around the eye, and in the creases between the thickened proximal portions of the oral tentacles, also on the edge of the mantle, margining the oral aperture; from this the shell itself receives an inky border, which is continued from the blackened portion of the coil around the entire aperture. This line measures about 2 mm. in width and can be detected from the outer surface of the shell; it does not appear, however, in shells which have been carelessly cleaned.

Nautilus, as far as my experience goes, lives but a short time in confinement, twenty hours being the longest time I was able to keep one alive. And even from the beginning the animal was evidently not at its best. It is true that the conditions under which I observed them were unfavorable, for in no case were specimens brought me which had been confined less than three hours in a water bucket. And the best aquarium I could improvise was a tank which held only about two hundred liters of water. Changing the water at frequent intervals had little effect in keeping the animals alive. I soon found that it was difficult to know just when the animal did die, for it retains a very lifelike position. This I discovered as follows: with a view of finding whether at any time movements became more active I caused my helper to watch a specimen through out the night, the man to call me in case it showed change of position or any peculiar behavior. In the early morning I was told that the animal had shown no movements, a statement I soon had little reason to doubt, for I found my Nautilus dead. On returning it to the water I observed that it floated, retaining, however, its customary position; and so it stayed in spite of my efforts to cause it to sink. This is the only case in which I observed a specimen remain at the surface; and the thought suggested itself that it was from such floating specimens that the idea originated that Nautilus was more or less a surface form.

The usual position and appearance of nautilus in confinement are sketched in Fig. 6.[1] It will be noted that the lower rim of the hood lies in approximately a horizontal position, the dorsal



FIGS. 6, 7, 8. — Diagrams showing the position of Nautilus at different stages of closing.

fold of the mantle protruding slightly above the concave hinder rim, entirely concealing the black portion of the shell. The

[1] In the photograph which Willey has given (*Q. J. M. S.*, 1896, p. 179), the living specimen appears to be somewhat droopy, or perhaps it is just recovering from its alarm at being confined in so small a vessel, evidently a museum jar. Thus the base of the hood has shrunken away from the shell, especially at the sides (but then this is not unusual), and the dorsal fold of the mantle which normally rises to the upper margin of the black area of the shell can hardly be seen; the tentacles, too, sag down in a way which I think rather uncustomary, cramped, perhaps, by the smallness of the glass vessel. My impression, too, is that they have drawn down the ventral lip of the shell somewhat lower than is usual. How easy it is, though, to criticise a zoölogical result, even in the form of an admirable photograph, and to forget that it may have been my own specimens that were sickly!

eye protrudes conspicuously, but not, however, beyond the plane of the surface of the shell ; its lower rim lies more or less within the lateral indentation of the shell's aperture. This indentation, as will later be seen, is apparently a provision to enable the animal to see, even when largely retracted. The tip of the siphon is also seen to protrude (*S*), and between it and the hood lie the closely arranged oral tentacles. When the animal is in this position the proximal ends of the tentacles appear long, narrow, and moderately well rounded ; the distal portions taper out delicately, the tips extended and weaving together, somewhat as shown in the figure. Examining a similar specimen from in front (Fig. 10), we observe a more or less regular arrangement of these tips of the tentacles ; they cluster together, lying in the main in front of and almost concealing the opening of the mouth. In this position the shape of the dorsal surface of the hood is well shown ; there is a median flattened tract from which the sides shelve away, moulding the hood to the whorl of the shell and to the region of the eyes and tentacles. Looking at a specimen from above, we obtain the appearance shown in Fig. 12. This, however, pictures a more retracted stage. It will be seen that the hood is neatly adjusted to the outline of the aperture of the shell. Anteriorly the distal ends of the tentacles protrude in a tuft and are arranged quite symmetrically.[1]

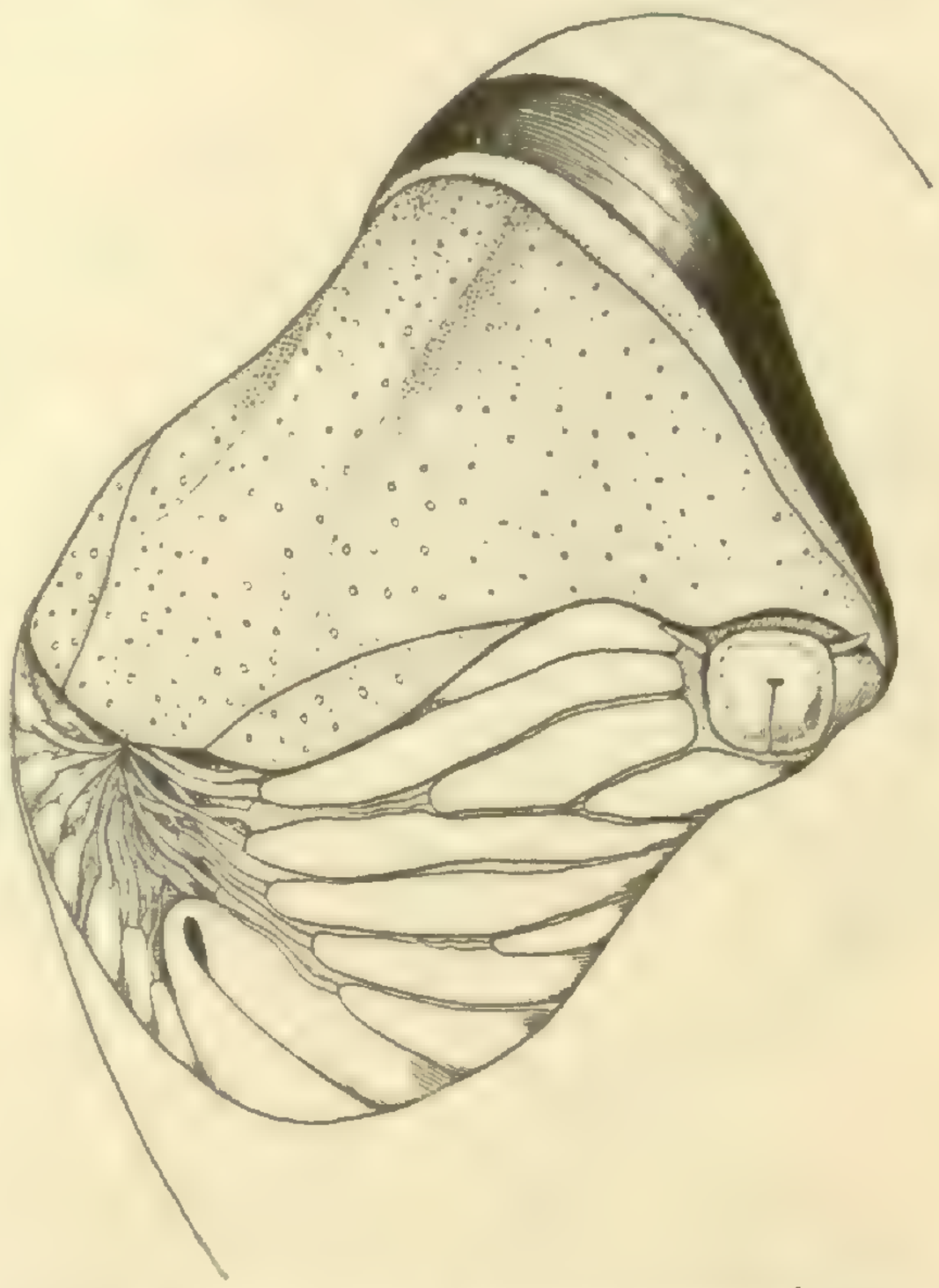
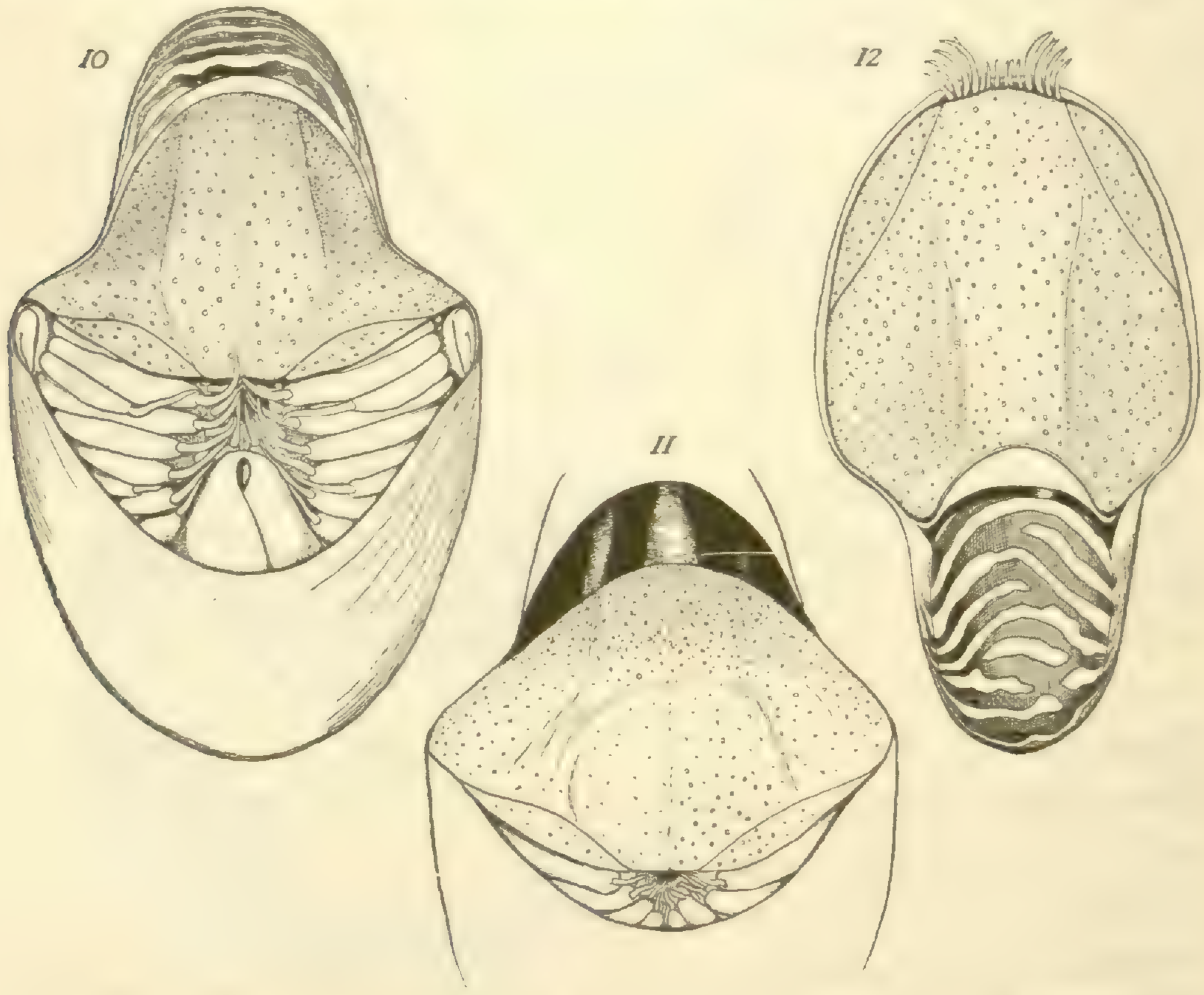


FIG. 9. — Nautilus somewhat retracted, in resting position. Oral region, shown in three-quarter view.

[1] Willey (*Q. J. M. S.*, 1898, Pl. X) figures them in complete extension, diverging widely at the sides of the head, and still symmetrical in position.

Appearance when retracting. — When a specimen is picked out of water (and it bears handling with considerable composure) it slowly retracts, presenting the appearance shown in side view in Figs. 7 and 8, in three-quarter view in Fig. 9, in dorsal view Fig. 12, and in oral view Fig. 11. The first symptoms of retraction are seen in the shortening of the tips of the tentacles and in the drooping of the hood. These processes



FIGS. 10, 11, 12. — 10, Nautilus, front view, showing oral region, at an early stage of retraction. 11, Oral region at a late stage of retraction. 12, Dorsal aspect of Nautilus resting and partly retracted, showing tentacles.

are more or less rapid, depending upon the condition of the animal; and I am led to believe that under normal circumstances retraction can take place very quickly. In the shortening of the tips of the tentacles the fleshy proximal portions become notably stouter, at the same time more angular in section, dovetailing one beside the other so tightly that their common outer surface is flattened where it is later to be opposed to the inside of the shell. Observe also that the hood becomes notably depressed, at the same time exposing the dorsal rim of

the mantle; this then recedes, exposing the blackened portion of the shell. The eye is still seen peering over the notch at the lip of the shell. In this stage of retraction the animal will often remain for many minutes; if handled somewhat roughly it will retract still further, presenting a stage of closure shown in Fig. 8. Here the hood has closed over the aperture of the shell like a lid, or rather like an operculum; it has shrunken and flattened somewhat at the same time; behind it the mantle has receded, leaving the blackened area of the shell much in evidence. At the anterior end (Fig. 11) can still be seen the turgid ends of some of the tentacles. The final closure of the aperture of the shell appears to take place by the bending down of the anterior flap-like portion of the hood, a process, however, which does not readily occur. Only by sharply stimulating this region have I seen total closure, and even then but for a few moments. If undisturbed, even if kept out of water, the animal slowly reopens. The hood first rises sluggishly, often separating itself behind from the shell, and the tentacles begin to protrude. More slowly does the mantle expand again over the blackened area. If still kept out of water the tentacles protrude and hang down over the edge of the shell in a flaccid mass.

If an animal be taken out of water and held in an inverted position it will at first close just as has been described. After some time, hours (Professor Worcester tells me) in the case of specimens just out of water, minutes in the case of those which have been kept in aquarium, the heavy fleshy "head" of the animal will begin to droop downward, and will finally appear as shown in side view in Fig. 14 and in ventral view in Fig. 15. Whether under such circumstances the animal will ultimately fall out of its shell, I neglected to observe. I found, however, that by this means one can readily remove the animal from the shell and without breaking the delicate siphuncular tube. The muscles attaching the body to the shell occupy very definite areas within the latero-dorsal region of the aperture and at the sides of the coil of the shell; and these areas are landmarked quite clearly in the inverted animal. The muscles may accordingly be separated from the shell, one's

finger-tips answering adequately for the purpose. Before the operation is completed, however, the siphuncular tube should be loosened; this is effected by thrusting the hand within the shell below the siphon. At such treatment the animal retracts, but after several attempts the finger-tips find their way to the base of the siphuncle. In the inverted position the animal presents several peculiar features. The hood is bent and misshapen, and evidently possesses considerable plasticity. Adjacent to it the black portion of the shell is largely exposed, owing to the retraction of the mantle. The tentacles are tumid, retracted, and are closely pressed together. The eyes stand out prominently, like mushrooms. The siphon shows its broad separation from the tentacular portion of the head, and hangs downward as a stout, muscular mass; at its base on either side droops a thin fold of the mantle (*M A*). Of this the inky black edge corresponds to the black line already referred to as lying within the aperture of the shell. The entire mantle is now greatly retracted: its posterior ventral rim (*M P*) exposes a portion of the extensive mantle cavity, in which, although not shown in the figure, can be seen the gills. The animal while in this position is observed to give an occasional gasping movement which involves the adjacent mantle rim as well as the siphon folds; these are expanded and contracted quickly.

The Tentacles and their Movements, Extension and Retraction. — Extension and retraction play an important and constant part in the economy of these organs. The maximum extension observed is about as shown in Fig. 8; shortly after death it is possible, however, to draw out the tentacles considerably further, to the degree which I have indicated in the swimming Nautilus of Fig. 1, or in the diagram, Fig. 13, *C*. Indeed, I suspect that the tentacles can be everted even further than this, should the animal be so disposed. It is of course doubtful if this protraction can be carried to the degree which would cause the obliteration of the distinct boundary line which separates the distal from the proximal portion of the tentacles. Judged from their varied movements, these organs have come to be highly specialized in the matter of

lengthening and shortening, if for no other purpose than that of their protection within the shell. How these processes came to be evolved there is no good evidence for determining; an attractive hypothesis would connect them with the transverse foldings which permit the tentacles to serve as adhesive organs. And one can readily conceive that a process of shortening based upon the principle of transverse folds would result in the production of one highly effective fold, to the loss or detriment of the rest. This highly serviceable fold would of course be represented in the present boundary between the proximal and distal portions of the tentacle. According to such a view the proximal portion has now lost all traces of transverse segmentation, becoming, in fact, but a kind of sheath for the rest. The distal portion, on the other hand, on account of its varied movements, has still retained them. It will accordingly be seen that the slender distal portion of the tentacle is not to be regarded as the homologue of a single highly specialized sucking organ, as some writers have maintained. There is, I believe, no evidence that such sucking organs are to be looked for in the tetrabranch division of the cephalopods. On the contrary, this division, possessing tentacles many in number and adhesive at a multitude of points, could scarcely have required the specialized sucking rings which characterize the few-armed cephalopods.

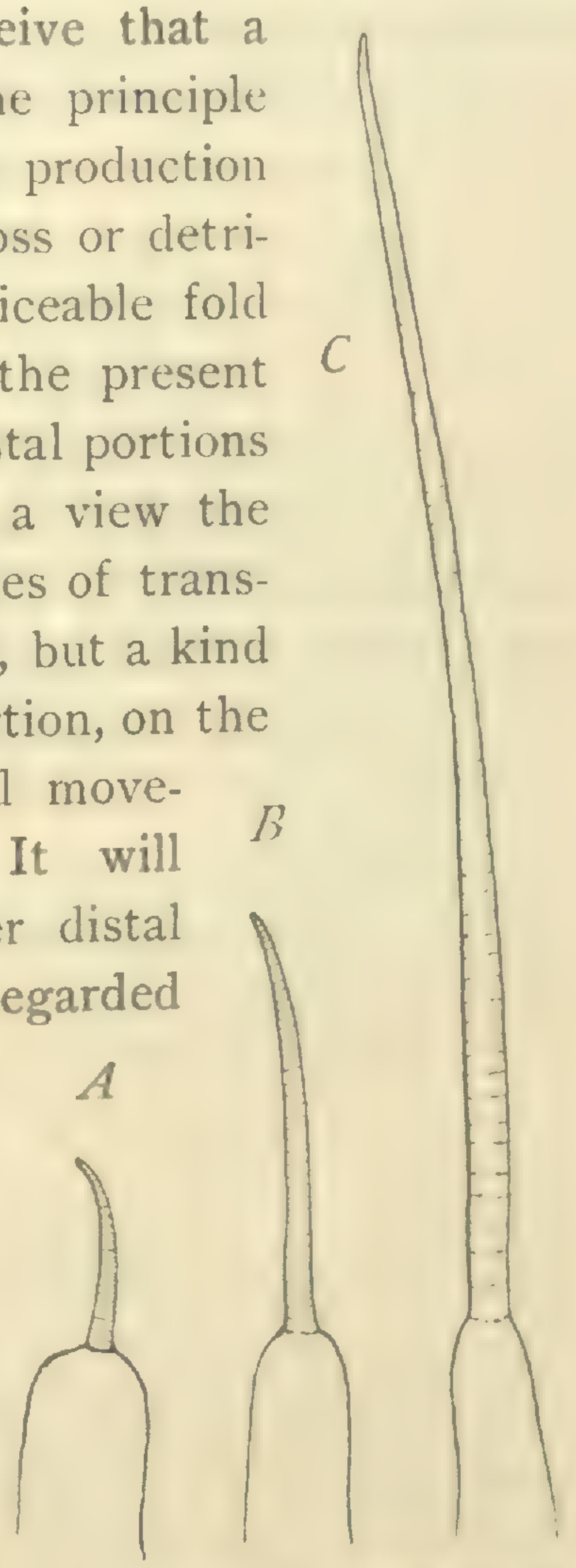


FIG. 13. — Diagram of tentacle at different stages (*A*, *B*, *C*) of protrusion.

The Movements of Nautilus. — In captivity Nautilus remains in one position, sometimes for hours. This sluggishness, however, may reasonably be due to the shock it suffers in being suddenly brought to live in surface water. Slight movements of the ends of the tentacles are sometimes the only signs that the animal is still alive. Spasmodically, however, a strength

of movement is exhibited which convinces the observer that under natural conditions Nautilus must be looked upon as an active form.[1] It will suddenly sweep from the bottom and bump its shell into a side or corner of the aquarium, — this, too, with considerable energy. At the shock the animal sinks to the bottom, partially retracts, and again remains almost motionless. In these spasmodic movements the animal rarely rises more than three or four inches from the bottom, although on one occasion I observed it swim nearly to the surface, a vertical distance, however, of not more than forty-five cm. During the night-time the movements appear to be if anything less active than during the day. A curious rocking movement is often observed, the animal swinging forward or backward, or from side to side, but never to a degree suggesting a change in the resting position. Rotation — that is, turning the shell to right or left — is very readily accomplished, and without, as far as I could see, any special movement on the part of the siphon. A very slight change in the direction of the water current exhaled from the siphon, aided by a slight leaning of the shell, is evidently enough to account for this ready movement, for the animal is delicately poised and little mechanical impulse is needed. Occasional distinct movements of the hood begin, and tentacles are observed. The hood will partly close, then open again, somewhat abruptly. The tentacles show a peculiar weaving movement; sometimes they separate quite widely from one another, and then converge. In their function as adhesive organs they will attach themselves somewhat delicately to objects presented to

[1] Professor Moseley, in his interesting *Notes of a Naturalist on H. M. S. Challenger*, observed that Nautilus swims with its tentacles "extended radially from the head, somewhat like the tentacles in a sea-anemone; but each pair has its definite and different direction, which is constantly maintained." As far as my own observations go, the exact position of the tentacles during swimming is not easy to determine, for the specimens were closely confined and their movements sudden and short; I am led to conclude, however, that the tentacles are drawn together during sustained movement, like those of other cephalopods. And in this position I represented them, somewhat stiffly, perhaps, in Fig. 1. For the above volume, together with other references to Nautilus, I am indebted to Professor Ijima, who kindly secured them for me in the University of Tokyo and forwarded them to Misaki.

them.[1] When roughly touched, however, they will merely retract. On one occasion only did I observe the separation of the tentacles around the mouth and the protrusion of the jaws, to the degree shown in Fig. 1. I was not able to induce the animals to feed. I noticed, however, that in specimens which had recently died little effort is needed to draw the jaws forward to a surprising degree, so that they would stand well outside of the proximal portions of the tentacles. And I think that there is little doubt that the jaws can be used in a position which one would

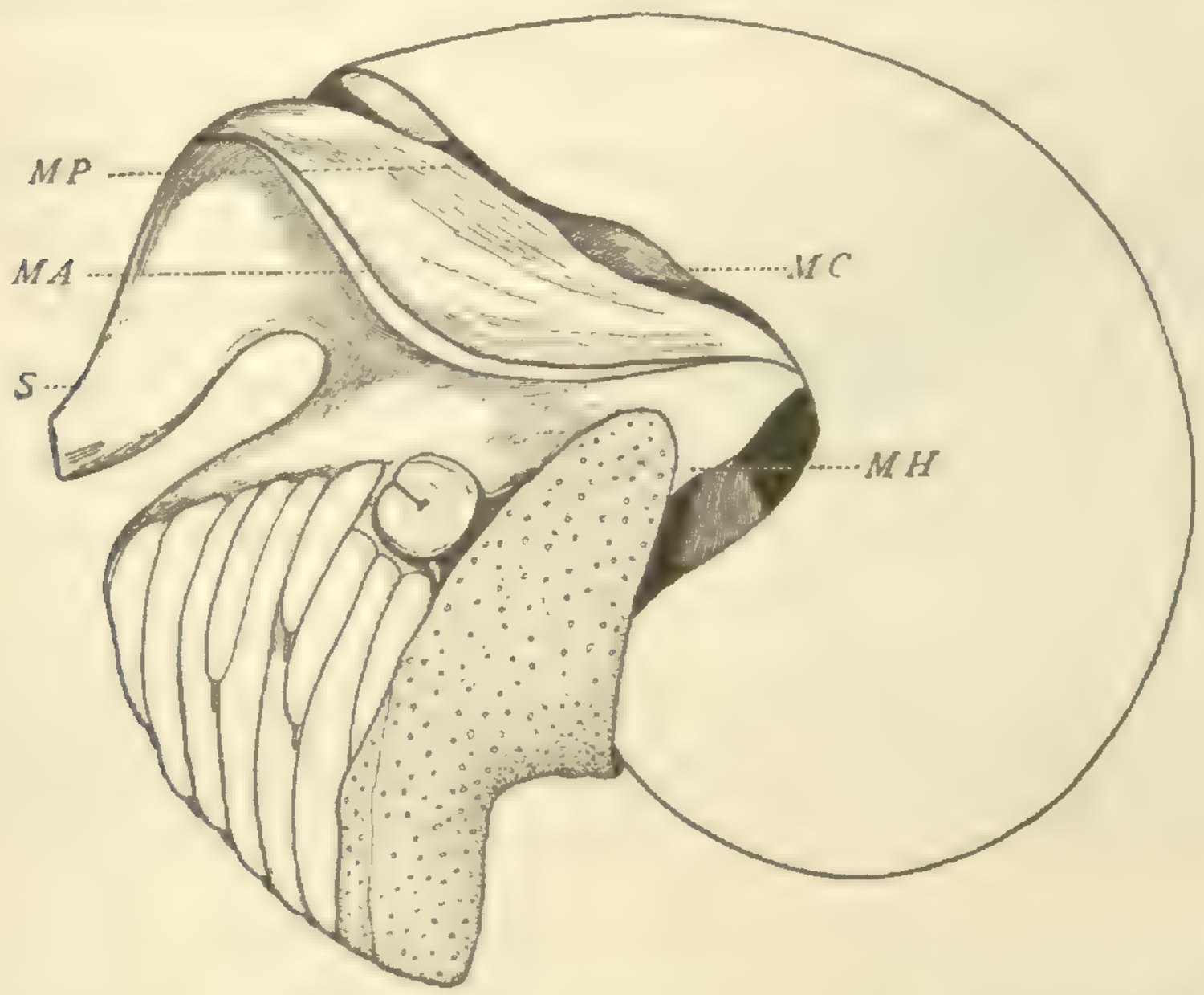


FIG. 14.—Side view of Nautilus shown hanging out of its shell. This position is assumed after the animal has been held for some time hood downward.

hardly be led to expect from an examination of preserved specimens. Accordingly I infer that the tentacles are of less importance in the mechanical operation of feeding than is popularly believed. When the jaws are drawn out, as above noted, the tongue is found to lie far forward, curving outward between the tips of the jaws. Nautilus is already well known to have a similar diet to that of other cephalopods. Its fondness for animal food in a decomposing condition I note from hearsay. I found, however, that with its strong jaws and rasping

[1] Willey in his notes convinces me that I have not examined the tentacles when at their best, for he has seen them "adhere so firmly to a foreign body as to become torn away from the animal when the foreign body is forcibly removed." (*Q. J. M. S.*, 1898, p. 207.) His figure indicates that the tentacles when firmly attached become partially retracted, at least as far as their tips are concerned.

tongue it has little difficulty in feeding upon animals which are enclosed in a stout leathery skin. Reference has already been made to the spasmodic movement of the siphonal flaps and of the ventral rim of the mantle; under normal conditions the movement of exhalation is practically confined to the siphonal flaps, the ventral rim of the mantle being closely apposed to the aperture of the shell, just as the portion of the mantle behind the hood is apposed to the black region of the coil. It is not difficult to convince one's self that under natural conditions Nautilus is well able to protrude its "head" quite widely from the aperture of the shell in a way suggested by the position of Fig. 14.

FIG. 15. — Individual of preceding figure shown in somewhat ventral aspect.

Breeding Season, and the Question whether Eggs and Young have been collected by Fishermen.—From the condition of the reproductive organs in five specimens examined I am led to infer that the breeding of Nautilus in the region of southern Negros extends over a considerable season; this evidence, however, is too meager to be of particular value.[1] There is certainly, it seems to me, a fair chance of securing the embryos of Nautilus in this region if what I learned from the fishermen is to be relied upon. One of these men in particular gave such a satisfactory account that I cannot very well doubt that he had at some time seen deposited eggs. And it may be well to state parenthetically that no data were given to the fishermen which they could make use of in their reminiscences. The fisherman in question assured me that on one occasion, as nearly as he could remember it was during the early part of the summer of

[1] I find that Willey at first believed that in the case of Nautilus in New Guinea "reproduction takes place all the year round" (*Q. J. M. S.*, 1896, p. 176). After his observations in Lifu, however, he abandoned this conclusion, stating that "it now seems probable that the breeding of Nautilus . . . is subject to a definite law of periodicity" (*Nature*, 1897, p. 403).

1900, he noticed eggs attached to a fish-cage in which Nautilus had been taken : there were several eggs, he did not remember how many, but they were attached not far from one another, and stood up on end, each as big as two joints of his finger, and with a leathery skin. Their color was white, and — this was the curious part of his story — they had brown markings across them [1] which reminded him of those on the shell of the adult animal. It was from the latter feature that he was sure the eggs belonged to Nautilus. His account seemed to me worth repeating, since it is hardly probable that he could have invented offhand so tolerably accurate a story, or that he would have been apt to describe an object which has nothing to do with eggs of Nautilus and yet resembles them so clearly. Moreover, there is a greater probability of accuracy when one considers that such a man is apt to be a skillful observer in matters relating to his work, — a thing which a stay-at-home zoölogist often finds hard to realize. I was assured on every hand that small specimens of Nautilus are relatively common during the fishing season ; that specimens whose shell is the size of a silver dollar are often thrown away, and that still smaller specimens are occasionally taken, in spite of the large mesh of the fish-cage.

[1] Could these be the rows of foldings and "fenestrations" of the outer egg capsule which Willey described (*Nature*, 1897, p. 402)?

BASELEVELING AND ITS FAUNAL SIGNIFICANCE, WITH ILLUSTRATIONS FROM SOUTHEASTERN UNITED STATES.

CHARLES C. ADAMS.

In considering some of the peculiarities of the fauna of the southeastern United States I wish to call attention to certain principles that are fundamental to an understanding of the present distribution of many forms of life, especially those of land and fresh-water. Especial stress is laid on the relation of physiographic changes, and baseleveling in particular, to faunal changes and to the differentiation of land and fresh-water animals.[1]

The necessity of correlating the results of baseleveling, and river histories in particular, with the distribution of habitats and their fauna, was very emphatically impressed upon me in connection with some studies upon the Pleuroceridæ of southeastern United States. This relation was clearly demonstrated to me when I learned that the former course of the Tennessee River from Chattanooga was direct to the Gulf *via* the Coosa-Alabama system. Having thus become fully convinced of the great biological significance of the baseleveling factors, it was of considerable interest that I later learned that Woodworth ('94) had already appreciated this significance.

In a general way, this relation of physiography to topographic and geographic distribution has been well understood, but such studies need to be carried out in more detail. The geologists, from their familiarity with the physiographic processes, seem to have had a better appreciation of this relation than zoölogists. Woodworth ('94) has fully realized in a detailed way the influence of the baseleveling processes upon faunal changes.

[1] I am under obligations to Messrs. Salisbury, Hayes, and Campbell for permission to use their figures and to Prof. E. A. Birge of the Wisconsin Geol. and Natural History Survey for the loan of the cuts for Figs. 1, 2, and 3.

His paper is of great value to the general student as well as to the special student of faunal problems.[1] I find that he had anticipated many of the conclusions to which I had come, but, on account of their imperfect recognition, they will be well worth repeating. Geologists have been primarily concerned with the submarine aspect of physiographic changes. Chamberlin has discussed this in a very suggestive paper ('98).

Since there is a very evident correlation between the erosion of the land and the deposition of the eroded material in the sea, we are able to see that under some circumstances both the submarine and subaerial factors of physiographic change must be taken into consideration in explaining habitats and the struggle for existence of aquatic organisms. This may be illustrated if we suppose that as a continental shelf becomes reduced in area the crowding of its fauna might force some of its members into fresh water, a habitat with a relatively poor fauna, which consequently is open territory.

It appears that many biologists are unfamiliar with the idea of baseleveling. For this reason the following brief account is given, showing how rivers cut down land and tend to reduce it to a baselevel. If a comparatively level country be elevated out of the sea a few hundred feet, and rains begin to work upon it, the slight inequalities of the surface will cause the waters to collect in the hollows and then run off, carrying detritus and cutting a trench or gully. This trench becomes with succeeding rains deeper, wider, and longer as it cuts its way into the uplands, and thus valleys may be formed. With this growth or increase of the area of valleys there is an increase of lowland and cliff habitat and a decrease in the upland habitat. These progressive changes are beautifully shown in Figs. 1, 2, and 3, after Salisbury. It is important to notice here the changes in the relative proportions of the habitats, with a premium placed upon those forms which can

[1] Dr. H. C. Cowles has recently applied these principles to the study of plants:

The Physiographic Ecology of Chicago and Vicinity; A Study of the Origin, Development, and Classification of Plant Societies, *Bot. Gazette*, vol. xxxi (1901), pp. 73–108, 145–182.

The Plant Societies of Chicago and Vicinity, *Bull. of the Geographic Society of Chicago*, No. 2, 1901.

occupy the habitat that is increasing in area. These changes will produce tension lines between the inhabitants of the various habitats.

With regard to the river fauna, at first when the fall of the river is great, rapid-water forms have the advantage, but with the development of sluggish, meandering streams upon bottom land, quiet-water forms find a home. Since the lowland or swampy conditions begin at the mouth of the stream, quiet-

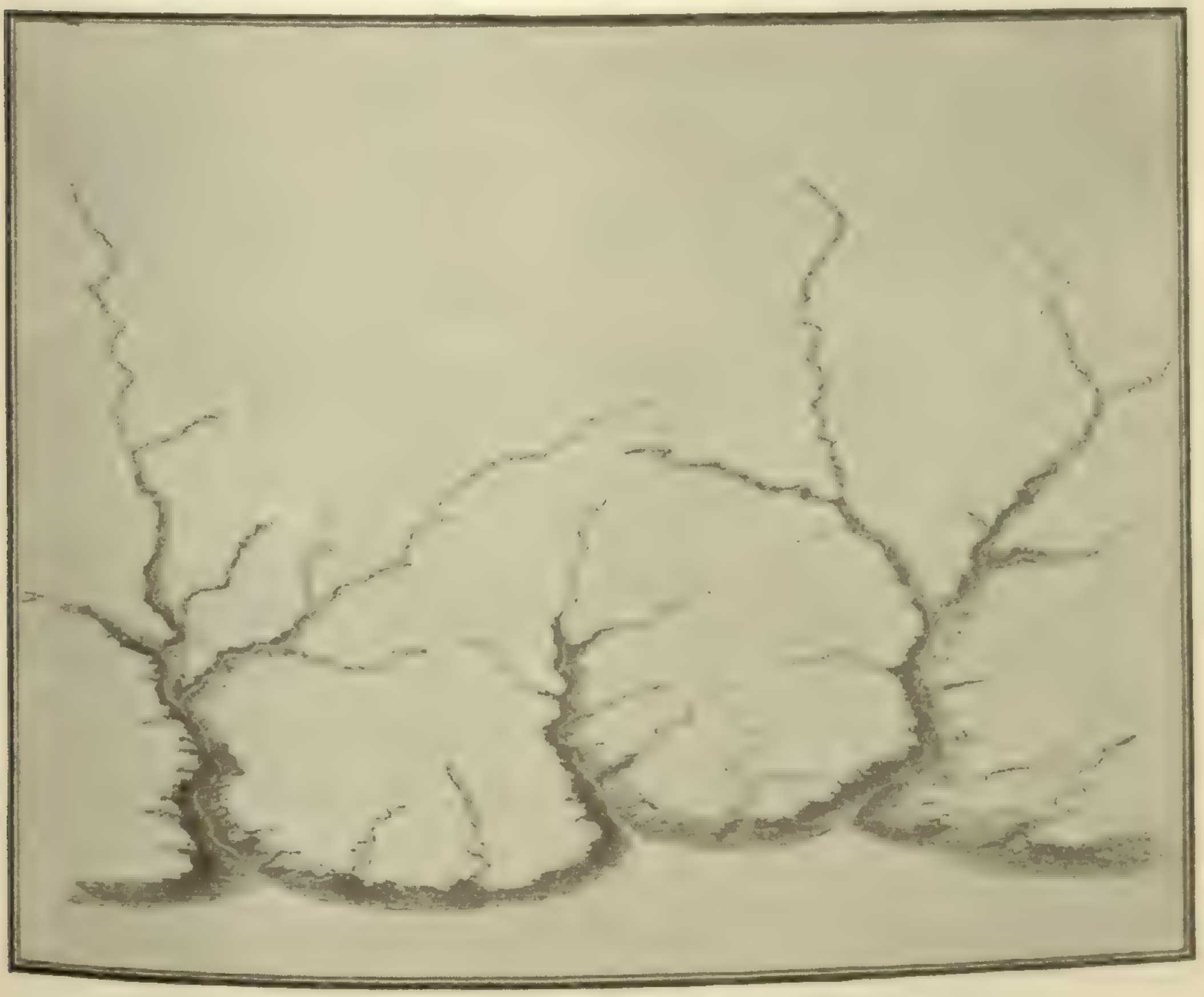


FIG. 1.—Young valleys. (After Salisbury.)

water forms will be introduced there, and with the extension up stream of lowland conditions this fauna is led in that direction; similarly, the head of the valley leads *its* rapid-water fauna in the same direction. Thus there is a definite succession of forms working up the valley, and, in a certain sense, by passing down stream one gets a recapitulation of the types of fauna which inhabit a given point of the stream during its ideal history. Dendritic tributary streams help to carry these same conditions in diverging directions, thus leading the fauna in various directions toward the divides.

Later on, with the wearing away of the inter-stream uplands, which at first were flat-topped, but which become more and more reduced by the dendritic etchings of the smaller streams, the divides gradually become more sharp, and the country

FIG. 2. — Valleys of later stage. (After Salisbury.)

reaches its maximum degree of roughness and cliff habitat, and consequently the greatest isolation of its streams and their faunas. By degrees these sharp divides are lowered, and head-water streams favorably located begin to capture fellow streams with their faunas, and thus there is a mixing of rapid-water faunas.

The time of maximum roughness in the topography coincides with that of maximum isolation, but with the fusion and concentration of drainage lines a period begins which favors wide distribution by the removal of barriers; thus in a country approaching baselevel a wide distribution of the fauna will be greatly facilitated with a premium placed upon the lowland fauna. This stage of wide distribution favors interbreeding,

and thus a period of swamping by intercrossing may be produced. The cliff fauna would have its maximum distribution and area of habitat when the country was at its maximum roughness.

It will not be necessary here to go further into the details of these processes, as the preceding remarks, with an examination of the diagrams, will suffice to show that these principles may be applied almost indefinitely, but the details vary greatly in different localities. One point perhaps needs special emphasis, and that is, we must think of these processes as *active* and taking place before our eyes.

The bearing of these factors upon the large amount of endemism seen in southeastern United States will be illustrated by a few examples. The physiographic changes of this

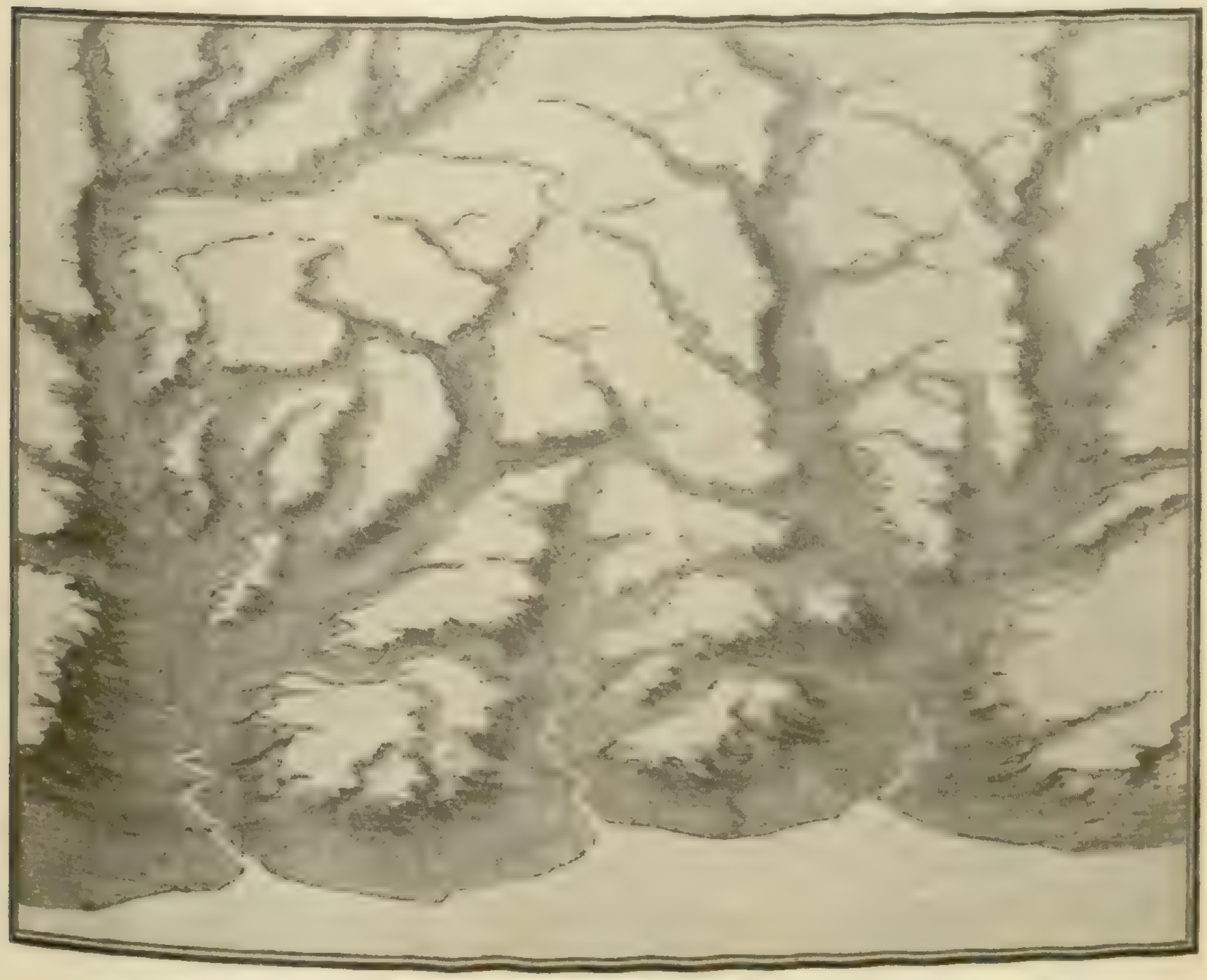


FIG. 3. — Valleys of further development than shown in Fig. 2. (After Salisbury.)

region have been very carefully studied, but comparatively little has been done to correlate these changes with the geographic distribution of the fauna of this region, and especially with its endemism. I hope, by calling attention to a few of these

correlations and to some of the principles involved, that others, more familiar with special groups of animals, may be led to make similar comparisons and correlations, and also to emphasize the fact that causal and genetic faunal studies must in the future take into account these factors, if work of permanent value is to be done. Biological surveys will, carried out in this way, become decidedly more than faunal lists, with miscellaneous biological information. In order to emphasize certain aspects of the baseleveling processes special phases will be discussed under separate heads.

Migration of Divides.

The migration of divides has long been recognized as an important factor in the mixing of river faunas, but without a distinct recognition of it as a phase of the baseleveling process. The following examples will show the influence of the migration of divides upon faunas. But first, attention will be called to some of the facts of the distribution of the family Pleuroceridæ, or Strepomatidæ of the older authors. This family is distinctly North American, living forms occurring here only. Tryon's monograph ('73) on this family, from which I take my data, recognizes four hundred and sixty-four species. Excepting those species whose exact locality is not definitely known and certain Pacific coast forms, most of these are limited to the Tennessee River and its tributaries above Florence, Alabama, and to the Coosa River. Two-thirds, or about three hundred, of these species are confined to these two river systems.

The region in which this family reaches its maximum development in both individuals and species is remarkably limited and is bounded by Tryon as follows. On the "*North*, by the Tennessee River and tributaries. The Cumberland Mountains prevent the dispersion of the species of this river to the northward until its course is directed into Alabama. Here the character of its species (which we will again allude to further on) changes, and they become gradually less numerous and of greater geographical dispersion as the river runs toward the west. *East*, the mountain range of the Blue Ridge, running

southwestwardly into the interior of northern Georgia; thence, the Chattahoochee River and tributaries, to within a hundred miles of the Gulf. *South*, the species are restrained from

FIG. 1. Map of Appalachian valley, which is the area of maximum differentiation of the Pleurocerids. After Hayes and Campbell.

spreading by the influence of the Gulf of Mexico. *West*, the Alabama, Cahawba, and Black Warrior Rivers and their tributaries, those of the latter reaching almost to Florence, on the

Tennessee River, which may represent the northwestern point of our boundary.

"These limits are necessarily imperfect, but, nevertheless, include at least three-fourths of our species within an area of three hundred miles extent, either north and south or east and west." By reference to Fig. 4 (after Hayes and Campbell), one will see that these limits are practically those of the Appalachian valley, and thus enclose a natural physiographic region.

Again, Tryon remarks: "Assuming the Ohio River as a dividing line, we find that ninety-five per cent of all the species originate south of it."

So much for these general facts of the distribution of this family which are necessary for an understanding of the influence of the migration of the divides upon them.

With the above facts of the distribution of these shells fresh in mind, about two years ago I learned from Hayes's ('95) paper of the view that the upper Tennessee River formerly flowed by way of the Coosa-Alabama Rivers into the Gulf. I saw at once in this an adequate explanation for the peculiar distribution of many of these shells in these two river systems. Since the data for this paper have been collected Mr. C. T. Simpson ('00) has published similar conclusions, drawn from the Unionidæ. According to Hayes's and Campbell's ('94), and also Hayes's ('99), opinion, the Tennessee River above Chattanooga was captured by a westward-flowing stream, and thus led away from the Gulf by the Coosa-Alabama to the Gulf again by way of the Ohio and Mississippi. Thus we see that the region in which the maximum development of this family is reached was *broken into two parts* (Fig. 5). The bearing of this upon the shell fauna is very marked.

This family is divided into two sections, and as to their distribution Tryon (*loc. cit.*, p. xl) says: "While the *Trypanostomoid* forms attain their maximum development in size and number in the Tennessee River, they are to a very great extent replaced by the *Goniobasic* forms in the Coosa River, which is undoubtedly the metropolis of the latter. The most striking genus of each of these groups is absolutely confined to the respective streams in which the groups had their origin.

Thus, Io and Schizostoma are inhabitants, the first of the Tennessee and branches, the second of the Coosa, and neither of them are elsewhere found." This is an excellent illustration of how the migration of a divide may favor differentiation.

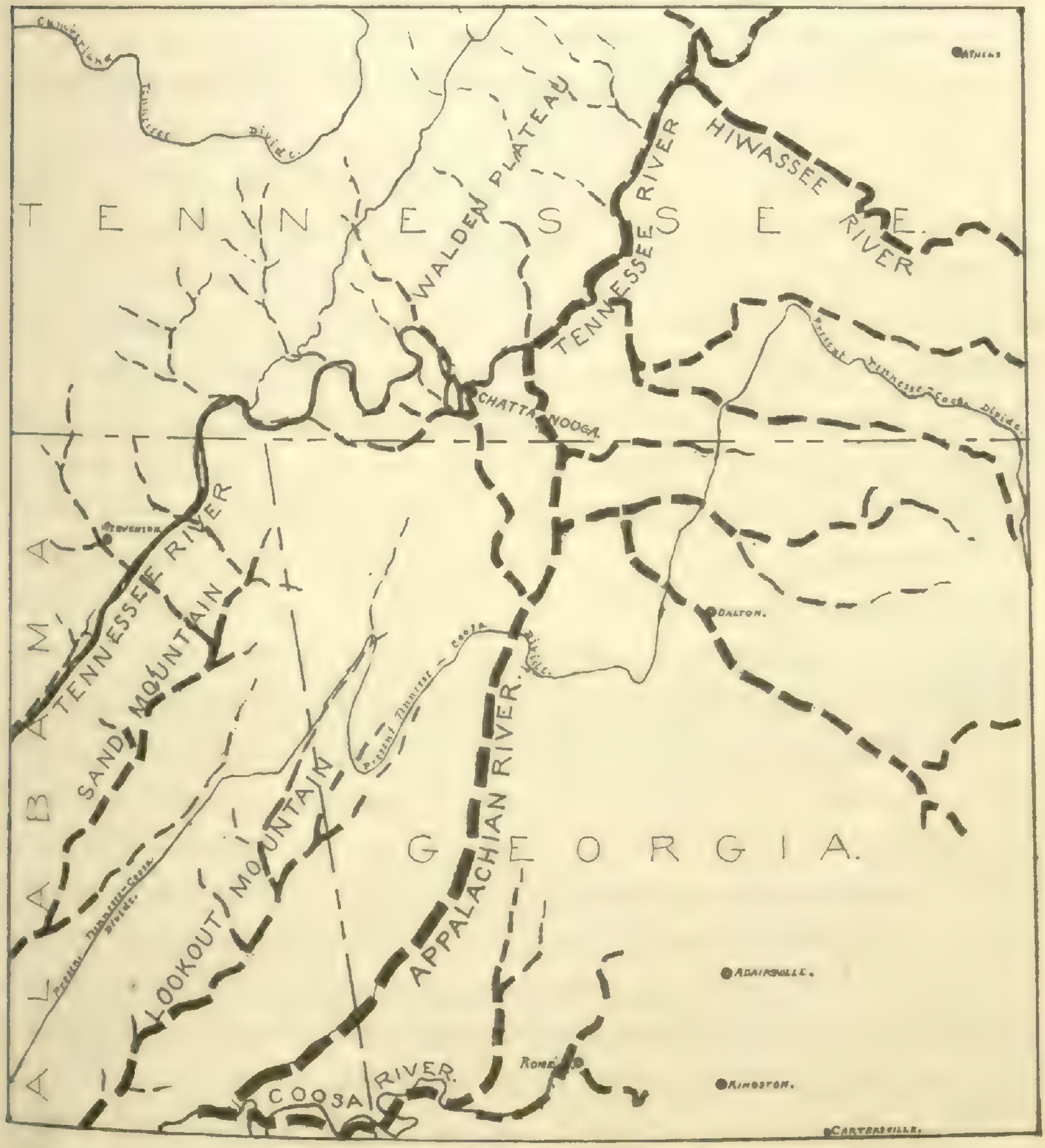


FIG. 5. — Map showing ancient (broken line) and present (continuous line) drainage in the vicinity of Chattanooga. (Adapted from Hayes, '99.)

The family has thus been broken up into two parts, both geographically and biologically.

The genus Pleurocera is credited with eighty-four species, twenty-three of which are found in Tennessee, and twenty-one are apparently peculiar to it. This same genus is represented in the Alabama system by fourteen species, and three of them are peculiar to it. "These species," says Tryon, "are generally

confined, however, to those portions of the Coosa and branches that approach to east Tennessee." Lithasia and Pleurocera are other genera divided in their distribution between the two systems. In the genus Strephobasis one species (Bitæniata) is found in the Black Warrior of Alabama drainage and in the Tennessee River at Chattanooga.

In the Goniobasic section there are two types of shells: one group is characteristic of the Tennessee and the other of the Coosa. In the genus Goniobasis, about ten of the elevated smooth species are found in the Tennessee, and about the same number in the Alabama system. Tryon (*loc. cit.*, p. xlviii) says of this genus: "There are over sixty species in the group which I have designated as 'compact and ponderous' for want of a better name. They are essentially a distinct group from the other Goniobases, and all the species except three are peculiar to the branches of the Alabama River."

Consequently, we see that this family reaches its maximum development in two distinct river systems, the upper Tennessee and the Coosa-Alabama, which formerly formed one river system (Fig. 5), and that by the diversion westward of the upper Tennessee, by the migration of its divide, this fauna has been split into two parts, each part having several genera, as well as species, in common. This process has led to an isolation of the Coosa-Alabama fauna and a mixing of the waters of the upper Tennessee with those of the Mississippi valley. In faunal studies some of the most striking peculiarities of the Tennessee River are very apt to be overlooked if we consider it a part of the Mississippi system only.

That these two systems have been separated for a considerable period of time, or that these forms have evolved very rapidly, is shown by the fact that it is the genera or groups of species which are found common to both streams rather than the individual species.

The family Pleuroceridæ is not the only group which has divided by the diversion of the waters of the Tennessee. The family Viviparidæ has a geographical distribution very similar to that of the Pleuroceridæ, its greatest variety being found in southeastern United States. The genus Tulotoma is confined

to the upper part of the Coosa River, and Lioplax has two species, one from the Coosa and the other from the Mississippi valley drainage. The species *Campeloma ponderosa* is found in both river systems.

An interesting illustration comes from crayfish. *Cambarus spinosus*, *extraneous*, and *erichsonianus* are found in both the Tennessee River and in the head-water parts of the Coosa-Alabama system.

A head-water fauna is very different from a lowland fauna; thus a knowledge of the habitats of animals will furnish criteria by which we are able to recognize, to some degree, the conditions under which divides have migrated. Since valleys continually lead their rapid-water fauna to the divides, these forms are the first which become transferred when they are shifted. What evidence is there to support this view? This is well shown if we consider those forms which are the *first* to surmount mountain barriers.

The Rocky Mountains have been a very formidable barrier to our fauna, there being but few passes or gaps through them. The fish fauna on each side of these mountains in the United States are remarkably distinct, but two species, according to Jordan ('96, p. 118), are found on both sides of this great barrier, and these species are very naturally rapid-water species, and not lowland forms. These two fish are the Rocky Mountain trout (*Salmo mykiss* Walb.) and the Rocky Mountain whitefish (*Coregonus williamsoni* Gir.). In the Appalachian Mountains the upland living brook trout (*Salvelinus fontinalis* Mitch.) illustrates the same point, it being found on both sides of the range.

Extension of Lowland Faunas into Uplands by Baseleveling.

River valleys are well known as highways for the dispersal of animals. These valleys, of course, are not always due to the process of baseleveling, but in the southeastern Appalachians we have good illustrations of the extension of a valley due to this process. The valley of the Tennessee River above Chattanooga is an excellent illustration of this. By means of

a narrow neck of lowland being carried back into the uplands an isolated, elongated land habitat is developed which reminds one of river isolation. Merriam's Life Zone Map ('98, plate) shows that there is an extension of the Upper Austral Zone into the Transition Zone due to the Tennessee valley. With the baseleveling process the isotherms gradually migrate up the valley and thus help to make it possible for the fauna to follow. Of course valleys, of whatever origin, may act as highways of dispersal.

It is important in this connection to recall the more or less definite succession of forms up the valley, because the problem of dispersal among some animals is largely a problem of the *continuous* distribution of the habitat.

Segregation of the Upland Faunas by Valleys.

Correlated with the extension of the valleys into uplands is the segregation of the uplands by the growth of the valley. This influence is beautifully shown by the land shell fauna on each side of the Tennessee valley. Since the Tennessee valley divides the uplands of the Cumberland plateau from those of the Smoky Mountains, I was led to anticipate that this isolation, which has existed for a considerable period of time, would show upon the land shell fauna, because these animals are very sensitive indicators of such influences. Later I was interested to learn that Pilsbry ('00) had very recently divided the "Cumberland sub-region" of Binney into an eastern and western division, corresponding to the uplands segregated by the Tennessee valley. He gives about twenty species and varieties characteristic of the Cumberland plateau, and about twenty-five to the Smoky Mountains. The French Broad River has for a long time separated the Great Smokies from Roan Mountain, and corresponding with these facts it has been found that six forms are peculiar to Roan Mountain and about a dozen to the Smoky Mountains.

Influence of Baseleveling upon Tension Lines.

The relation of the faunas of the different levels or base-levels to each other is also important from the standpoint of tension zones. On account of the large area which they may occupy at certain stages of topographic development these zones have great importance, for in them there is a large population subject to a peculiar environment and hence liable to important evolutionary changes. A stage of equilibrium is not reached here, as erosion makes this area relatively unstable and subject to continual changes. It is important to determine which is the more powerful, the physiographic or organic influences, in the production of these lines. The powerful influence of the physiographic processes in general leads one to expect that at first the physiographic factors will dominate, but later, in a fairly uniform habitat, the struggle will become more organic. In the study of dispersal and distribution of animals, it is important to see that the physical conditions lead, and that in a more or less definite succession the flora and fauna follow; thus the fauna comes to fit the habitat as a flexible material does a mold.

The time is passed when faunal lists should be the aim of faunal studies. The study must not only be comparative, but *genetic*, and much stress must be laid on the study of the habitat, not in a static, rigid sense, but as a fluctuating or periodical medium. The bearing of faunal studies upon the problem of differentiation and the origin of species, is very close, and in our search for the factors we must not lose the perspective, and overlook those factors which are fundamental and work through long periods of time.

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NOTES AND LITERATURE.

ANTHROPOLOGY.

The Seri Indians.[1] — It is especially fortunate that Seriland should have been explored by an ethnologist eminently fitted to describe the physiographic features of that little-known region. Professor McGee's memoir upon "The Seri Indians" is furnished with a new topographic map, a detailed description of the country and of its fauna and flora, as well as a succinct account of the arts and social institutions of the natives.

After presenting a comprehensive summary of Seri history, the author deals with the somatic characters of the people. The Seri differ from other Amerinds in their physiological and physical characters as strikingly as in their demotic. They are remarkable especially for their fleetness of foot to an extent that we should regard as quite incredible were it made known to us merely by travelers' tales.

The description of Seri demotic characters more nearly approaches completeness in the chapters devoted to Symbolism and Decoration, Industries and Industrial Products, and Social Organization. Personal decoration is confined almost entirely to facial painting, and that is a feminine prerogative. In discussing the "significance of decoration" Professor McGee outlines a scheme of progressive development from what he terms automacy to autonomy that is intricate but interesting. Industrial development is surprisingly low among the Seri. The "industrial use of stone is fortuitous and temporary." The author offers a new classification of primitive stone art based upon his observations among the Seri. The protolithic stage is that in which the stones are not shaped to conform to an established pattern; the technolithic, wherein the stones are fractured or otherwise shaped. Seri marriage customs are instructive to the student of social organization; they exhibit an almost unique moral test, and show a deep-seated interest in the maintenance of the tribal autonomy. The Seri are polygenous, apparently because of the reduction in the number of warriors in recent years.

[1] *Seventeenth Annual Report of the Bureau of American Ethnology*, 1895–96. Washington, D. C., 1898 (distributed 1901). 344 pp., map and plates.

In addition to the store of geographic knowledge this memoir is a positive contribution to ethnologic science of the highest value. It establishes a new linguistic stock (Serian), it affords illustrations of priscan phases of culture of extreme rarity, and the author advances many suggestions of theoretic interest. FRANK RUSSELL.

ZOÖLOGY.

Schmeil's Zoölogy.[1] — This work was originally prepared for students in German Gymnasia and "Realschulen," and has as its primary object a disciplinary use of the facts of zoölogy. It tells certain facts, it leads the student to infer other facts and reasons by numerous and carefully worded questions. It differs from the old-time zoölogies, which merely gave a description of selected animals, by some very important features. It takes representative forms and describes them from an œcological standpoint; showing how they are adapted to their environment, and how they are fitted to a certain kind of life. Then follow shorter descriptions of allied forms. There is a minimum of structural details throughout, but the biological side, so interesting to young students, is everywhere emphasized. We would advise that all secondary schools teaching zoölogy have a copy of this work in the reference library; its price and its unnecessarily large size forbid its use with us as a class-room text. K.

Herrick's Home Life of Wild Birds. — The subtitle of Professor Herrick's book,[2] if it is understood that only the home life of birds is to be studied and photographed by the new method, will serve as a guide to the nature of this very valuable addition to the list of books dealing with bird life. Professor Herrick has, by the help of the strong parental instinct in birds, overcome the difficulties with which the photography of birds in the wild state has hitherto been attended. Instead of trusting to mechanical devices for arranging

[1] Schmeil, Otto. *Text-Book of Zoölogy*, treated from a biological standpoint, translated from the German by Rudolf Rosenstock, M.A., edited by J. F Cunningham, M.A. London, Adam and Charles Black, 1901. xvi + 403 pp.

[2] Herrick, Francis Hobart. *The Home Life of Wild Birds.* A New Method of the Study and Photography of Birds. With 141 original illustrations from nature by the author. New York and London, G. P. Putnam's Sons. 1901. 148 pp.

the camera in the branches of trees, and taking a chance shot or two when the bird shyly returns to the nest, he cuts off the limb or twigs on which a nest containing young birds is fixed, and removes it to a favorable situation near by. Then, concealing himself and his camera in a small green tent within a few feet of the nest, he waits for the parents to adjust themselves to the new conditions. This they do in a surprisingly short time. In a few hours the old site is forgotten, and the birds are as firmly attached to the new one as if they had themselves chosen it. The operations of feeding, cleaning, brooding, and other incidental actions of old and young may now be observed and registered with a completeness and clearness impossible under the old method.

Professor Herrick's book contains introductory chapters dealing with the instincts and habits of birds and the psychological principles involved in the successful practice of the new method, followed by other chapters explaining and illustrating the method as employed by Professor Herrick. Seven of these are devoted to a detailed account of the home life of a number of our common birds as observed at close range. The text is supplemented by a series of photographs, which surpass for clearness and scientific value, as well as for popular interest, anything of the kind heretofore published. The birds thus treated belong for the most part to the passerine order; the night hawk and the kingfisher are the only exceptions. The very fact that in the study of such familiar birds as the robin, catbird, and cedar bird, we are offered so much interesting observation, much of it original in its accuracy of detail, gives a good idea of the value of the method, and promises rich results when it is applied to less familiar birds.

The concluding chapters of the book deal with general questions, such as the force of habit, fear, etc. There is an excellent index; the paper, typography, and the reproduction of the photographs are of the best quality. The excellence of the book in such matters is in itself evidence that it is intended not as a scientific treatise, but as a popular "bird-book," and if it is reviewed as such, it should be awarded only the highest praise. There is, however, much reference in the first and the three last chapters to the questions of instinct and habit, and they are treated in several paragraphs in a purely philosophical spirit. The author, moreover, puts in at the outset a strong protest against what he justly terms the "gross anthropomorphism" which characterizes much of what is now written on animals. A first reading of Professor Herrick's book, however, will

leave the ordinary reader with no very clear notion of the author's ideas on the subjects of instinct, habit, fear, etc. His conclusions, though in accord with such an excellent authority as Principal Morgan, are by no means clearly presented. The reader follows on one page a rather discursive account of an encounter with a black snake, and, turning the page, finds himself confronted with a difficult paragraph on the instinct of fear. The anecdotes which are to elucidate the principles laid down, or to be laid down, overweigh the reasoning, and often have no especial bearing. More systematic arrangement of ideas, an occasional paragraph recapitulating conclusions, and an introductory line here and there to show the bearing of the coming anecdote would greatly increase the value of the semi-scientific chapters. It might have been better, moreover, to avoid the dogmatic attitude of the paragraphs on the nest-building instinct on page xvi, and make reference at least to the possibility of tradition playing a part in handing on the art of nest building. The nests built by chaffinches turned loose in New Zealand (A. R. Wallace, *Darwinism*, p. 76) may be adduced as evidence that a bird like the robin perhaps does not make mud nests "as instinctively as it lays blue eggs."

Of undoubted scientific value are Professor Herrick's observations on the food offered to the young, on the way the food is carried to them, and on the sanitation of the nest. The sensitiveness of the gullet of young birds and the parent's habit of taking out food not immediately swallowed and transferring it to another gullet, throws light on what has been hitherto an obscure process. It is doubtful whether the home life of other passerine birds will vary much from the types observed by Professor Herrick, but there is, as he suggests, a great unexplored field in the orders.

It is as a popular but unusually accurate and thoughtful presentation of a subject at present much in vogue that the book has a special claim to recognition. Professor Herrick's patience, ingenuity, and quick power of observation deserve the success with which the book is sure to meet. The wealth of extraordinarily good illustrations, the intimate relations with birds into which the reader is brought, will fascinate any one who has any interest in the study of living animals. If the author's style lacks the inspiration which a more imaginative temperament might give to it, his scientific habit of mind, joined to his evident enthusiasm, make him an excellent guide and model for those who may begin observation by his method. The method is admirably suited for instruction in summer schools.

and has been already adopted in at least one outdoor school of natural history.

The objections to the method arising from the possibility of danger to the young thus removed from the site selected by the parent are carefully discussed by Professor Herrick. It is well, however, to repeat his warning against interfering lightly in the home life of wild birds. In the opinion of the present writer, none but trained naturalists should use the method, for they, if animated by Professor Herrick's genuine love for the individual bird, will be on their guard against the dangers likely to be incurred. R. H.

The Fishes of Ohio is the title of a paper by Professor Raymond C. Osburn, published as a *Bulletin of the Ohio State University* (Ser. 5, No. 20). The paper is a descriptive faunal list of the fishes known to occur within the borders of the state. In the Introduction is given an historical sketch of ichthyological investigation of Ohio fishes.

Each species is briefly, though sufficiently, described; following each description is a list of localities in the state where the species is known to occur; there is also given a few notes concerning its habits, etc. Keys to facilitate identifications are also given. The paper is neatly and carefully gotten up and indicates very careful and thorough work.

The publication of descriptive faunal lists like the present one, by institutions which have the facilities for such work, is to be highly commended.

In a footnote *Notropis fretensis* (Cope) is regarded by Mr. Osburn as being allied to *Notropis heterodon* Cope and *Notropis cayuga* Meek, a belief shared by Drs. Jordan and Evermann. It is, however, a *Notropis rubrifrons* (Cope), differing from the typical *rubrifrons* in having but eight anal rays. In his original description Professor Cope calls attention to the fact that this species resembled *Minnilus*. *Notropis rubrifrons* usually has ten anal rays. It is not, however, uncommon to find some specimens with nine or even eight anal rays.

The type of *Notropis rubrifrons* is in the Philadelphia Academy of Sciences, where I had the pleasure of examining it a few years ago.

S. E. MEEK.

The Otocysts of Decapod Crustaceans. — An exhaustive study of the structure, development, and function of the otocysts of decapods

has been made by C. W. Prentiss.[1] In Palæmonetes, as in most other macrurans, the otocyst is a sac lodged in the basal segment of the antennule and opening dorsally by a constricted aperture partly covered by a scale-like fold. The sac is lined with cuticula which at the aperture is continuous with the animal's external shell. On an elevation rising from the floor of the sac is a horseshoe-shaped double row of from forty-five to fifty-eight hairs. The hairs are plumed and instead of being straight, as the tactile hairs of the outer surface are, they are bent so that the distal part of each shaft makes an angle of 120 degrees with its shorter base. Each hair is attached to the sac by a thin-walled chitinous bulb, thus allowing the hair as a whole to move freely. In the tangle formed by the crossing of the hairs are lodged fine grains of sand and organic detritus constituting an otolith. Every hair has at its base a group of matrix cells by which its chitinous wall was secreted. A single nerve fibre leads from the base of the hair inward to the brain, where it terminates in many fine branches. Each fibre has on its course a single cell body, so that each "auditory" hair is innervated by a single neurone. The same is true of the tactile hairs of the general surface, but the olfactory hairs, on the contrary, are innervated each by as many as a hundred neurones. Not only do olfactory and tactile hairs differ in this respect, but they can also be distinguished by the fact that in the olfactory hair the nerve fibres pass far out through the axis of the hair towards its tip, but in the tactile hair the single fibre ends at the base of the hair. An otocyst essentially similar to that in Palæmonetes was found in Crangon and in Cambarus.

In the common green crab, Carcinus, the otocyst is closed, contains no otolith, and its hairs are arranged in three groups instead of one. The innervation of these hairs is the same as in the macrurans studied.

Every time a shrimp or crab casts its shell, the cuticular lining of the otocyst, the attached hairs, and the otolith, if such be present, are discharged. As a preparatory step to this change, the matrix cells form a new hair under each old one, the new hair being half inverted in that the tip is pushed back into the base as the end of a finger of a glove might be infolded into the rest of the finger. When the skin is shed the new hairs are in part drawn out by the retreating skin to which they are slightly attached and in part

[1] Prentiss, C. W. The Otocyst of Decapod Crustacea: its Structure, Development, and Function, *Bull. Mus. Comp. Zoöl.*, vol. xxxvi (1901), pp. 167–251. 10 pls.

expanded by blood pressure. The discharge of the contents of the otocyst is through the natural aperture of the cyst, which remains open in macrurans but rapidly closes in brachyurans. Where an otolith is discharged, as in the shrimp and other macrurans, the animal immediately after ecdysis gathers in its claws small sand grains and puts them in the opening of the otocyst. These become attached to one another and to the auditory hairs by secretions from the walls of the otocyst and thus form a new otolith.

The otocyst was originally described as an organ of hearing. When sounds are produced under the water of an aquarium in which shrimps are contained, the animals respond by a darting movement if near the source of sound. The vibrations which stimulate the shrimps, however, can be *felt* by the submerged hand at a distance of ten to twenty centimeters greater than that at which the shrimps react. Moreover, shrimps respond to these vibrations even after the otocysts are removed. The reactions are inhibited, however, by the removal of the antennæ and antennules with their tactile hairs. It follows from these observations that whether we call the reactions auditory or tactile, the otocysts take little or no part in producing them.

If, then, the otocysts are not stimulated by sound, what is their function? When the otocysts are removed, shrimps swim with a more or less rolling motion and may even turn ventral side up. Their equilibration is thus shown to be seriously interfered with. When their eyes are covered with opaque materials so as to blind them, they swim with little or no rolling motion; but when both blinded and deprived of otocysts, they move with the greatest irregularity, swimming sometimes on their backs and sometimes in irregular spirals. Their capacity for orientation has disappeared completely. and as the experiments show, though the eye plays some part in keeping the animals upright, the otocyst is the chief sense organ in originating orientation reflexes. The otocyst is stimulated through the pressure of the otolith on the sensory hairs, as is shown by the ingenious experiments of Kreidl, who induced shrimp to form otoliths of iron particles instead of sand grains and then found that the animals became oriented to the lines of force of a magnet as they formerly did to gravity. These results are confirmed by Prentiss.

The development of the otocyst is also dealt with. It is not present in the first larval stage of the lobster nor is it more than indicated in the second and third, but at the fourth stage it suddenly appears with almost the full complexity of its adult structure. The locomotion of

the animals shows a corresponding change; young lobsters swim with great irregularity until the otocyst is developed, after which they regularly assume the upright position. It is also interesting to observe that immature lobsters newly molted and not allowed to form a new otolith reassume the rolling movements of their earlier stages and continue in these until opportunity is given them to form new otoliths. Thus the results obtained by Prentiss confirm completely the view first advanced by Delage, namely, that the otocyst has as its chief function that of originating orientation reflexes. That it is not an organ of hearing cannot with so much certainty be maintained, although its importance in this respect has assuredly been shown to be very slight. P.

Recent Work on Anopheles. — In a recent study on the geographical distribution of Anopheles in relation to the former distribution of ague in England, G. H. F. Nuttall records with L. Cobbett and G. Strangeways (*Journal of Hygiene*, Vol. I, January, 1901) a series of observations of general interest in addition to much that is purely medical. He finds that three species, *Anopheles maculipennis*, *A. bifurcatus*, and *A. nigripes*, occur in Great Britain in all districts formerly malarious, but extend into regions in which no ague is known to have been prevalent at any time. To-day Anopheles is most numerous in low-lying land containing stagnant or slow-flowing water and corresponding to the districts where ague was formerly prevalent. As the disappearance of this disease does not depend upon the extinction of Anopheles, possible causes, therefore, are: (*a*) a reduction in the number of these insects consequent upon drainage of the land; (*b*) a reduction of the population in infected districts by emigration; (*c*) the use of quinine; or (*d*) the extinction of another yet unknown intermediary host besides man capable of harboring the parasite. The coincidence of the geographical distribution of ague and Anopheles is certainly not as precise as claimed by Grassi, and probably the *numerical* distribution will prove of equal importance. The presence of Anopheles in non-malarious districts explains the occasional occurrence of ague if a malarious subject comes in from other parts.

In another paper on the structure and biology of Anopheles, Nuttall and Shipley (*Journal of Hygiene*, Vol. I, January, 1901) give a full summary of our knowledge, together with personal observations. Noteworthy is the fact that the larva of Anopheles, as also that of Dixa, browse upon matter adhering to the surface film, like

certain fresh-water snails and many Turbellaria. Palmate hairs on the third to the seventh abdominal segments, with branches in the form of a cup, constitute the means by which the larva cling to the surface film. The studies are to be continued, and from their precise and detailed character bid fair to become a most valuable source of information regarding the genus. H. B. W.

The Insect Book. — The complete title[1] indicates the effort of the author and of the publishers. The former is widely known for many valuable monographs, both systematic and biological, and for energetic and successful practical work; the publishers are equally well known for their enterprise in numerous undertakings tending towards the promotion of nature study. Such a combination should, it would seem, be eminently satisfactory. That it is not so is disappointing; that the title should be modified is evident. The *Insect Book* should not exclude the groups to which the "majority of collectors of insects confine their attention"; moreover, the standard must be low that considers the life histories "full"; the tables are confined to families or higher groups, and the bibliography, pp. 405–416, copied with but few additions from Banks's List (*Bulletin 24*, Division of Entomology, U. S. Department of Agriculture, 1900), however useful from a taxonomic standpoint, is not of primary importance in a book planned "to encourage the study of life histories of insects"; moreover, the very evident deficiencies of Banks's work are unnoticed and the mistakes not only are uncorrected but are augmented.

The text is readable, though not altogether well balanced in proportion; it shows evidence of haste, of a lack of continuity, and also of the most important essentials for a popular book, namely accuracy and conciseness. Dr. Howard evidently does not believe that all praise should be left for the tombstones, but his extravagant words for several contemporary authors can but jar many of his readers.

Some of the errors of statement are amusing, others are serious: under the former may be placed the classification (p. 295) of the book under review as one of the "older books" relating to insects;

[1] *The Insect Book.* A popular account of the bees, wasps, ants, grasshoppers, flies, and other North American insects, exclusive of the butterflies and moths and beetles, with full life histories, tables, and bibliographies. By Leland O. Howard, Ph.D., Chief of the Division of Entomology, U. S. Department of Agriculture. New York, Doubleday, Page & Co., 1901. xxvii + 429 pp., 47 pls., 265 text illustrations.

among those of a more serious nature may be mentioned the reproduction (pp. 343, 344) of Scudder's original notation attributing a day song and a night song to *Oecanthus niveus*. These supposed "day" and "night" songs have long been known to be the songs of distinct species, and so far back as 1893 Scudder recognized his error and stated that a revision of his score was desirable.

The plates are all original; most of the text-figures have been previously used and the source is acknowledged, though not in all cases satisfactorily.

Very few of the illustrations, either in the plates or in the text, can be commended; this can be clearly seen by comparing the colored plates with those of Holland's *Butterfly Book*, and the text-figures with those from the same blocks as used in various publications of the United States Department of Agriculture and elsewhere; in the make-up of the book the plates are poorly placed.

Inconsistencies in typography and lack of ordinary care in proof-reading are so apparent that even an inexpert corrector of the press could not turn many pages without finding glaring errors. S. H.

Michaelsen's Oligochæta.[1] — When Dr. Michaelsen began his work he had before him no easy task, and it is safe to say that no student of this class of animals could have discharged his duty in a more satisfactory manner. The museum in Hamburg is in possession of the largest, and as regards species most complete, collection of Oligochæta, and when we remember that it has been brought together entirely by Dr. Michaelsen, it may be readily understood that the author has been eminently fitted for his work. The literature of this class of animals is already very large, and it is also so scattered that it is impossible for any one living outside of the large literary and scientific centers of Europe to procure or have access to all. Dr. Michaelsen has had access to all this literature, and has personally examined almost every species described by different authors, as far as they yet exist, and the result has been a work of the very highest value, and one which no student of the group can do without.

The first part of the book contains a list of abbreviations for reference to literature. It seems to the reviewer that it would have been better if such abbreviations had been adopted as are used by the publications abbreviated. This suggestion refers equally to

[1] Michaelsen, W. *Das Tierreich*. 10. Lieferung, Vermes, Oligochæta. Berlin. Friedlaender, 1900. xxix + 575 pp., 13 figs.

almost every publication issued, and is a subject worthy of international consideration. Next after the abbreviations we come to a systematic index. When we consider that this index of families and species occupies not less than sixteen pages in double columns, we may begin to comprehend the enormous increase in described species during the last few years. All in all, there are probably 1100 species of Oligochæta now sufficiently well described to be readily identified. As is well known, the majority of species of this class can only be identified by anatomical characters. This makes identification difficult without the aid of illustrations, and it is much to be regretted that so few are found in this otherwise so valuable monograph. The morphological part is confined to ten pages, and it is here that the want of illustrations is especially felt. The author introduces a number of new words to indicate structures, such as tanilobic, zygolobic, prolobic, etc., according to the various and different encroachments of the prostomium on the anterior somite, etc. Many of these names have been derived from the Greek and Latin and are most happily found, and we can only regret that the author has not seen fit to revise also the general nomenclature to such an extent that students of other languages could readily understand what parts and organs are referred to. Why not use, for instance, "spermatheca" instead of "samentasche," etc.? The larger part of the book is devoted to a systematic description of the species, their genera and families. These descriptions are models of conciseness, including all the principal exterior and interior characters necessary to define the species. A large number of names have been changed, priority being given to the oldest ones, according to the rules adopted by the German society of naturalists. In this department the author has made very thorough studies, and as a consequence we meet with many novelties which will be referred to in their respective places. Every genus is preceded by a key for identifying the species. Many will object to the style of key adopted. In our opinion the most desirable key in all systematic works is the one which, besides facilitating the finding of the species, at the same time gives us an idea of the systematic arrangement and relationships. The system adopted by the author gives no idea of the affinity of the species, but simply facilitates finding them. In adopting the present style of key the systematic review of the genera and species certainly suffers. This is especially the case in large genera, as, for instance, Dichogaster (Benhamia, etc.), where the species number over 150.

The treatment of the limicolide groups should prove especially interesting to the American students, as the scattered literature of these groups is especially difficult of access, as much of it is in Slavic languages. We are glad to see that the genus Ilyodrilus has been restricted to its three California species and separated from Branchiura, with which genus it has really no affinity. The treatment of Enchytræidæ is especially good, the author having previously studied this family, and being the first one to bring order out of the chaos which existed previous to his monograph on that family. Among innovations we remark the genus Lumbricillus substituted for Pachydrilus. It is to be regretted that this change should have been necessary, as we have already too many names with a similar sound. The family which probably interests us most is the large one of Megascolecidæ. This family is made to contain the majority of North American terrestrial earthworms. The most interesting fact connected with the family as defined by the author is that it is made to contain Ocnerodrilus as well as Diplocardia, Trigaster, Plutellus, Chilota, etc. The genus Achantodrilus, which a year ago contained more species than almost any other genus, is now restricted to a single species. The Old-World species of the once large genus have now been separated from the New Zealand ones, while the majority of the species have been referred to the genus Notiodrilus, etc. It is most interesting to note that as a result of the author's investigations we now find Achantodrilus placed next to Microscolex and its allied genera, while a few years ago these were referred to different families. The genus Plutellus has been resurrected, as is quite proper, but what will astonish the general student more is that Plutellus and Pheretima have been referred to the same family, — the reason being that we now place very little importance on the number of setæ in each somite, as long as the interior organs resemble each other. The author has had special opportunity to examine Kinberg's types in the Stockholm Museum. As a result of this investigation it has been possible to identify nearly all of Kinberg's genera and most of his species, and consequently many later names have to give way to the old Kinberg names, —Pheretima instead of Perichæta, etc. The subfamily Diplocardinæ has been well treated, and so has its near relative Trigastrinæ. The Zapotecia has been raised to a full genus, it previously having been considered a subgenus only. Dichogaster is made to contain both Benhamia and Dichogaster, which certainly is an easy way out of the difficulty in defining the relationship of these two genera. But even the author's

lately established genus Balanta has had to give way to the all-engulfing Dichogaster. A division into subgenera retaining such names as Benhamia, Balanta, and Dichogaster would probably have been more in accordance to the ideas of several other investigators, and would have served to give a better review of this genus — we confess one of the most puzzling in the class. Under Ocnerodrilinæ we now meet with the genus Kerria, the structure of which is the one that gave the clue to the relationship of these genera with one and two pairs of prostates. Several of the subgenera under Ocnerodrilus have been raised to independent genera. We have thus Nematogenia, Pymeodrilus, and Ocnerodrilus side by side. *Nematogenia panamæensis* has been raised to an independent species. Among the subgenera Enicmodrilus has been fused with Ilyogenia. It would have been an improvement if the species followed each other in the general text in the same manner as in the key, or *vice versa*: this is rarely the case. The name Geoscolecidæ has been changed to Glossoscolecidæ, the latter being an older name.

The last family, Lumbricidæ, has more of a negative interest to students in this country, as comparatively few indigenous species are found here. While it is true that several species of this family have been described as new from North America, it is doubtful if they really are indigenous, and we may find that the species so considered are mere importations. This fact is certain, that no new Lumbricidæ have been found west of the Rocky Mountains. All the species on the Pacific coast are undoubtedly importations from Europe, and a very careful search by the reviewer has failed to reveal a single new species of this family between Alaska and Central America. This is the more interesting as the Pacific coast is in many respects related to Japan and eastern Asia. Thus Pillsbury has shown that the dart-bearing Helices are only found on the Pacific coast of North America, while they are widely distributed through the continents of Europe and Asia. Similarly among the Crustacea the genus Astacus is found all along the Pacific coast, and in Asia and Europe, while the genus Cambarus is found only in central and eastern North America. Among plants also there is a similarity between the Pacific coast and Japanese forms. But when we come to the earthworms the conditions are different. As far as we know, not a single species is found common to Japan or Asia and the Pacific coast. The indigenous California species seem all to be related to antarctic ones, or rather to species from south of the equator and to genera which with good reason may be considered as

having emanated from a former antarctic continent. The indigenous terrestrial species of Lumbricidæ found in North America should for the present be looked upon with suspicion in connection with their true habitat. The family of Lumbricidæ has received model treatment in Michaelsen's monograph. The book ends with a very perfect register, — a desideratum not always found in transatlantic scientific works. Taking it all in all, this splendid monograph cannot be too highly praised. It is not only indispensable to all students of the class, but it is so complete that for the identification of the species the older literature is made almost superfluous. As regards nomenclature, Dr. Michaelsen's ideas are almost final; while as regards classification they are sure to remain unchanged for many years. A perusal of the volume shows one thing which should be encouraging to all students of earthworms; that is, compared to the terrestrial Oligochæta the limicolide forms are almost unknown, and it is evident that it is among the latter that the greatest novelties will be found in the future.

GUSTAV EISEN.

BOTANY.

A Botany for Children. — Professor Atkinson in an attractive little book entitled *First Studies in Plant Life*[1] follows the current practice of presenting vital phenomena to the young beginner, rather than details of form. The first part gives a brief account of the growth and parts of plants, the second and third discuss their work and behavior, the fourth gives the life story of a sweet pea, an oak, a fern, a moss, and a mushroom, and the fifth treats of the battles of plants in the world. The illustrations are of exceptional excellence. Many ingenious and simple experiments are introduced. Much of the text seems likely to interest young people, and any teacher may gain valuable suggestions from the book.

A prevailing fault, however, is a more or less obvious "writing down" to the young reader, becoming at times mere sentimentality such as intelligent children resent. It is hard to see how the following passage, for example, can serve any useful purpose: "Some will

[1] Atkinson, George Francis, Ph.B., Professor of Botany, Cornell University. *First Studies of Plant Life*. Boston, Ginn & Company, 1901. 12mo. xii + 266 pp., 308 figs.

tell you that such interesting plants as the ferns, mosses, mushrooms, and puffballs are *cryptogams*, and that therefore you should not try to read the stories they have to tell. But why call them cryptogams? That is a terrible word, that ought to be blotted out of the English language. Why not call them plants, as they are? They are just as much God's creatures as the dandelion and thistle and smartweed are. They are just as interesting too, and mean as much in our lives as they do."

Furthermore, it may be questioned whether some of the topics to which considerable space is given — as, for example, turgidity, plasmolysis, and various microscopic details — are really within the comprehension of young beginners. Every one who has studied children knows what confused and perverted ideas they will often get regarding matters of much greater simplicity than belongs to some of the physiological topics here presented. It is hard enough to give college students clear ideas of microscopic mechanisms and life processes.

Only a few errors of statement have been noticed, but there is one which is sure to bewilder the pupil. On page 14 it is said of the bean that the embryo plant (meaning the plumule) is attached to the cotyledons. Then on page 19 it is asked if this small object which looks like a tiny plant is the embryo, and the reader is left to suppose that it is. Finally, on page 22 the reader is told most impressively that all inside the seed coat and its lining is the embryo, and that the embryo thus includes the cotyledons.

F. L. S.

A New Publication on Woody Plants. — Houghton, Mifflin & Co. announce that they will issue next autumn the first part of a new publication, *Trees and Shrubs*, consisting of text edited by Professor Sargent, and plates from drawing by Mr. Faxon, pertaining to woody plants, particularly those adapted to the gardens of Europe and the United States, or of commercial or economic importance. The sample pages and plates that have been distributed with the prospectus show, as would have been expected, excellence in drawing and publication, and the happy mean between technicality and popular writing which mark the *Silva* is likely to be maintained by Professor Sargent in this new publication, which in size and general appearance will bear considerable resemblance to the *Silva*. Two parts, each consisting of twenty-five plates and costing $5.00, are expected to appear yearly.

The prospectus of this proffered work, curiously enough, raises a question that may bother the botanical nomenclaturists, for Pl. II and the accompanying text depict and describe what is called a new species in that much-vexed genus Cretægus, so that when the initial number of the publication appears it will doubtless be found necessary to refer in it to this prior distribution of the species referred to.

T.

Flowers and Ferns in their Haunts.[1] — Where to draw the line between pleasant summer reading and didactic literature is often hard to decide, and yet when we go to the country there is a limit to what our trunks will carry, so that some kind of discrimination becomes necessary. This pretty little book will hardly come amiss, from whichever point of view selected, though it may not hold the attention of the reader like a novelette nor suit the needs of a class in botany; but through its pages runs a chatty narrative that is pleasing, and the illustrations show much that can be done by aid of the camera when intelligently used. T.

The Dictionary of Gardening.[2] — As was stated in the *Naturalist* for November, 1900, the excellent *Dictionary of Gardening* of Mr. George Nicholson, curator of the famous Kew Gardens, which for years has been the reference book for gardeners wherever English is read, has had planned for it a supplement, bringing it up to the end of the century. The first volume of this supplement appeared in June, 1900, and a second volume, completing it, was distributed in July of the present year.

No more favorable place than Kew could be found for the elaboration of a compendious work on cultivated plants and the most successful ways of growing them. Not far from 25,000 species are said to be cultivated there. Kew is probably freer than any other establishment in the world from the common fault of botanic gardens, that the collections are grown uncritically under whatever names are attached to them when they are procured; and the very common, if often necessary, defect of botanical gardening, that a great variety of plants requiring dissimilar treatment are huddled together into a

[1] Wright, Mabel Osgood. *Flowers and Ferns in their Haunts*, with illustrations from photographs by the author and J. Horace McFarland. New York. The Macmillan Company, 1901. xix + 358 pp.

[2] Nicholson, George. The Century Supplement to the *Dictionary of Gardening*, a practical encyclopædia of horticulture for gardeners and botanists. George T. King, Hyde Park, Mass.

single house, where they collectively get the handling that best suits their average needs while it is not precisely adapted to any one species, is so far overcome at Kew that representatives of the great English plant houses sometimes go there for training. Mr. Nicholson is at once a good gardener and a lover and student of plants, and he has had the assistance of the best specialists at Kew and elsewhere, so that the *Dictionary*, as now completed, is a work alike valuable to the student of plants and their amateur and professional grower, and it cannot be spared from the shelves wherever plants are grown in variety. T.

Bailey's Botany.[1] — Carrying out his well-known ideas that botany in the secondary schools should begin with the commoner and grosser plants rather than by the use of those demanding the aid of the microscope, Professor Bailey has added another to the series of text-books already well and favorably known. Observation, experiment, and thought are thrust at the pupil throughout it, and the author very neatly acknowledges his obligation to hundreds of young people in many places for instruction "in the point of view," for the book, he tells us, is made for the pupil and, therefore, most appropriately views things as he sees them, even though it may enlarge his view of them before they are dropped. T.

Notes. — Under the guidance of Professors Flahault and Geddes, the late Robert Smith had begun the preparation of a series of botanical maps of Scotland, and since his death two sheets, respectively of Edinburgh and vicinity and northern Perthshire, have been issued in convenient pocket form, with a brief descriptive pamphlet, by John Bartholomew & Co. of Edinburgh.

W. N. Suksdorf has recently distributed excerpts from the *Deutsche botanische Monatsschrift*, extending over the period between November, 1898, and June, 1901, in which are published descriptions of a considerable species of Washington plants believed by him to be new to science.

Several new species and varieties of Californian plants are described by H. M. Hall in the *Botanical Gazette* for June.

Professor Dudley contributes an interesting and well-illustrated paper on the Big Basin Redwood Park to the *Forester* for July.

[1] Bailey, L. H. *Botany*. An elementary text for schools. New York, The Macmillan Company, 1900. xii + 356 pp., 500 figs.

A second part of Professor Nelson's "Contributions from the Rocky Mountain Herbarium," published in the *Botanical Gazette* for June, deals with various Colorado species and new western Arnicas and Eupatorieæ.

Four papers on the botany of the Yukon territory, as exemplified in the collections of R. S. Williams and J. B. Tarleton, are published in No. 6 of the current second volume of the *Bulletin of the New York Botanical Garden.*

The Botanical Seminar of the University of Nebraska has published the results of recent studies on the vegetation of that state.

A catalogue of the flora of Montreal Island, Canada, is being published in current numbers of the *Bulletin de l'Académie Internationale de Géographie Botanique.*

A systematic list of the plants collected by Schmidt on the Danish expedition to Siam in 1889 and 1900 is being published in the *Botanisk Tidsskrift.*

Pilger's "Beitrag zur Flora von Mattogrosso" is concluded in the second Heft of Bd. XXX of Engler's *Botanische Jahrbücher*, which, like other recent numbers, is also devoted in large part to studies of African plants.

Stanleya pinnatifida is figured in the *Gardeners' Chronicle* of June 15.

Dr. Small reviews the Mimosaceæ of the southeastern United States in the *Bulletin of the New York Botanical Garden* of May 27.

Rosa Engelmanni is figured in the April fascicle of *Icones Selectæ Horti Thenensis.*

Two species of Epilobium are characterized by Suksdorf in the *West American Scientist* for May.

An interesting "Study of the Papaw," *Carica Papaya*, by F. B. Kilmer, has run through several recent numbers of the *American Journal of Pharmacy.*

The Canada thistle is the subject of a revised issue of *Circular 27 of the Division of Botany of the United States Department of Agriculture*, by Mr. Dewey.

Several new Canadian gentians are described by Holm in the *Ottawa Naturalist* for July.

In the *Bulletin of the Torrey Botanical Club* for June, Dr. Small proposes the generic name Brayodendron for what has been known as *Diospyros Texana*, and describes several species in the genera Quercus, Æsculus, Hypericum, Azalea, and Dendrium.

Dr. Rydberg discusses the oaks of the continental divide north of Mexico in No. 6 of the current volume of the *Bulletin of the New York Botanical Garden.*

Vol. I of Kraenzlin's *Orchidacearum Genera et Species*, devoted to the groups Apostasieæ, Cypripedieæ, and Ophrydeæ, is completed with the 16th fascicle, the preface of which bears the date May, 1901. The volume, though its titlepage bears the date 1901, has been in publication since 1897.

An important article on the Texan home of *Pinus Cubensis*, by Professor Bray, appears in the *Forester* for June.

The report of the society *Isis* of Dresden for 1900 contains Parts I and II of a paper by Menzel on the gymnosperms of the North-Bohemian lignite formations, illustrated by a number of plates.

To the rather numerous check lists of ferns and fern allies is added another by B. D. Gilbert, bearing the imprint of L. C. Childs & Son, Utica, N. Y., 1901. Unlike most such lists, this one, which includes 438 numbers (species and varieties) which occur in North America above the Mexican line, contains a considerable number of critical notes and descriptions of new species.

A study of the nectar glands of *Pteridium aquilinum*, by Professor Lloyd, is published in *Science* for June 7.

A monograph of North American Sordariaceæ, by David Griffiths, constitutes the opening number of Vol. XI of the *Memoirs of the Torrey Botanical Club.* It is illustrated by 19 plates and several figures in the text, and contains a bibliography and index.

Part III of Arthur and Holway's "Descriptions of American Uredineæ," in No. 2 of the current volume of the *Bulletin from the Laboratories of Natural History of the State University of Iowa*, deals with rusts of several groups of grasses.

From a short paper by Professor Burt, published in the *Bulletin of the Torrey Botanical Club* for May, *Tremella mycetophila* Pk. appears referable to the genus Exobasidium.

Professor Atkinson, in *Bulletin 193 of the Cornell University Experiment Station*, gives an account of several of the fungi which attack the wood of shade and timber trees, — a subject heretofore investigated in this country by Dudley and von Schrenk.

The Manchester Literary and Philosophical Society, in a recent number of its *Memoirs and Proceedings*, prints an interesting lecture on the flora of the human body by Dr. Metchnikoff.

A doctor's thesis by S. L. Schouten, on the methods of securing pure cultures of micro-organisms from a single cell isolated under the microscope, has been issued from the University of Utrecht.

The present knowledge of the causation of certain plant diseases by bacteria is well brought out in a series of controversial articles by Professor Fischer and Dr. E. F. Smith, in the *Centralblatt für Bakteriologie und Parasitenkunde*, extending over the last two or three years, separates of which have recently been distributed by Dr. Smith.

Ule shows, in Heft 2 of the current volume of Engler's *Botanische Jahrbücher*, that a number of Amazonian Epiphytes seem to owe their distribution in part to certain ants which take to their nests in trees seeds of the other plants, some of which vegetate there.

The initial number of what promises to be an interesting series of articles on the pollination of Chilian flowers is published by Dr. Jokow in Heft 3–4, Bd. IV, of the *Verhandlungen des deutschen wissenschaftlichen Vereins zu Santiago de Chile.*

Prometheus, of June 12, contains the first of a series of articles by Sajó on plums and other fruits of American origin.

Mr. Pinchot has issued as *Bulletin No. 30 of the Division of Forestry of the United States Department of Agriculture* a very practical forest-working plan for a portion of the New York forest preserve, prepared by Messrs. Hosmer, Bruce, and Newell.

The Imperial Botanic Garden of St. Petersburg feels the need experienced by most active scientific establishments of a medium of publication under its own control as to time and other important conditions, and the director of the garden, Professor A. Fischer de Waldheim, announces the early appearance of the first number of a *Bulletin* which the Garden is to issue.

The *Plant World* for June contains several interesting short articles, among them one on the Cuban uses of Oreodoxa, one on Bermuda, and some suggestions as to the points to be observed in collecting specimens of Cratægus.

A portrait and appreciative little sketch of Thomas Meehan appear in the *Gardeners' Chronicle* of June 15.

PUBLICATIONS RECEIVED.

(Regular exchanges are not included.)

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THE PARASITIC ORIGIN OF MACROËRGATES AMONG ANTS.[1]

WILLIAM MORTON WHEELER.

THE genus Pheidole among ants is in several respects noteworthy. The unusually large number of species which it comprises afford valuable materials for the taxonomist, while their wide distribution and geographical variation cannot fail to be of interest to the ecologist. Of even greater interest are the certainly very diverse but still imperfectly known habits of the species of this extensive genus. And, finally, a fascinating congeries of morphological and physiological problems centers about the striking dimorphism of the sterile females, or workers of these ants.

In all the known species of Pheidole the worker phase is represented by two very different forms: small-bodied, small-headed, active workers proper, and larger, big-headed, sluggish soldiers. The latter are often of monstrous aspect, and their rôle in the social economy of the various species is still to be worked out in detail.

[1] *Contributions from the Zoölogical Laboratory of the University of Texas,* No. 22.

Until very recently the genus has been characterized as presenting no forms intermediate between the workers and soldiers, in contradistinction to the Old World genus Pheidologeton, the species of which exhibit even in the same colony numerous intermediates between the gigantic, big-headed soldiers and the minute workers. During the past year I found that two of our Texan and Mexican species of Pheidole (*Ph. kingii* André, *var. instabilis* Emery, and *Ph. vaslitii* Pergande) resemble Pheidologeton in presenting, in the very same nest, complete series of intermediates.[1] My attention was directed to this singular condition by Professor Emery, who has described the Texan *Ph. instabilis* from specimens collected at Austin. He has also rectified the synonomy of the Mexican *Ph. tepicana* Pergande, which presents a like polymorphism and has therefore led to the description of several species from soldiers of different dimensions.[2] Recently Professor Forel, utilizing some observations which I made at Queretaro, Mexico, has been able to rectify a similar error in the synonymy of *Ph. vaslitii* Pergande.[3]

In the present paper I desire to call attention to another peculiar modification of the workers of Pheidole, traceable to a perfectly definite, though obviously very different cause from that which must bring about the above-mentioned di- and polymorphism. June 3, 1901, I found at New Braunfels, Texas, on a shady hill that slopes to the lovely sources of the Comal River, two medium-sized nests of *Ph. commutata* Mayr. They were under stones about sixty feet apart. One contained ants of the typical dark variety of the species, while in the other nest both workers and soldiers were decidedly paler. In either case on lifting the stone my attention was attracted by several very large and conspicuous workers with huge abdomens, moving about among the workers and soldiers of normal dimensions. I had been collecting and observing the

[1] Wheeler, W. M. Notices Biologiques sur les Fourmis Mexicaines, *Ann. Soc. Entomol. de Belgique*, tome xlv (1901), pp. 199–205.

[2] Emery, C. Remarques sur un Petit Groupe de Pheidole de la Région Sonorienne, *Bull. Soc. Entomol. de France* (année 1901), No. 5, pp. 119–121.

[3] Forel, A. Fourmis Mexicaines récoltées par M. le prof. W. M. Wheeler, *Ann. Soc. Entomol. de Belgique*, tome xlv (1901), pp. 123–141.

little fungus-growing ants, *Cyphomyrmex rimosus* Spinola, which abounded on the same hill-slope, and all my bottles and bags used for living colonies were filled with these remarkable ants. I was therefore compelled to preserve in some small vials of alcohol as many of the Pheidole workers as could be captured. At the time I supposed that the huge individuals might represent some hitherto unknown guest-ant which had taken up its abode in the nests of the Pheidole.

On returning from my collecting trip I found that the conspicuous individuals were nothing more nor less than gigantic workers of *Ph. commutata*. One of the nests had yielded six, the other three, of these creatures. There were besides from each nest two or three somewhat smaller individuals clearly intermediate in size between the typical and the gigantic workers. All of these large individuals are evidently to be regarded as belonging to Wasmann's category of macroërgates,[1] since they are certainly "individuals which approach the females in an abnormal manner only in the size of the body, but in other respects (even in the development of the abdomen) are normal workers." Although the abdomen is enormously distended in the macroërgates of *Ph. commutata*, it is nevertheless clearly of the worker type.

The length of the normal workers of the Texan *Ph. commutata* is not greater than 3 mm. Many of them are scarcely more than 2.5 to 2.8 mm., which was the length of Mayr's type specimens from Florida.[2] The largest macroërgates, however, measure 5 mm., while the smaller ones are fully 4 to 4.5 mm. long. Thus the volumes of the normal workers and the extreme macroërgates would be in the ratio of 27 to 225 if they had the same form. But the abdomens of the latter are so enormously distended that the ratio must be 27 to at least 200. In other words, the large macroërgates are nearly eight times as large as the normal workers. They are even larger than the soldiers, which measure about 4 mm., though in this

[1] Wasmann, E. Die ergatogynen Formen bei den Ameisen und ihre Erklärung, *Biol. Centralbl.*, Bd. xv (1895), Nr. 16 u. 17, pp. 606–646.

[2] Mayr, G. Die Formiciden der Vereinigten Staaten von Nordamerika, *Verh. d. Zool.-Bot. Ges.*, Bd. xxxvi (Wien, 1886), pp. 419–464.

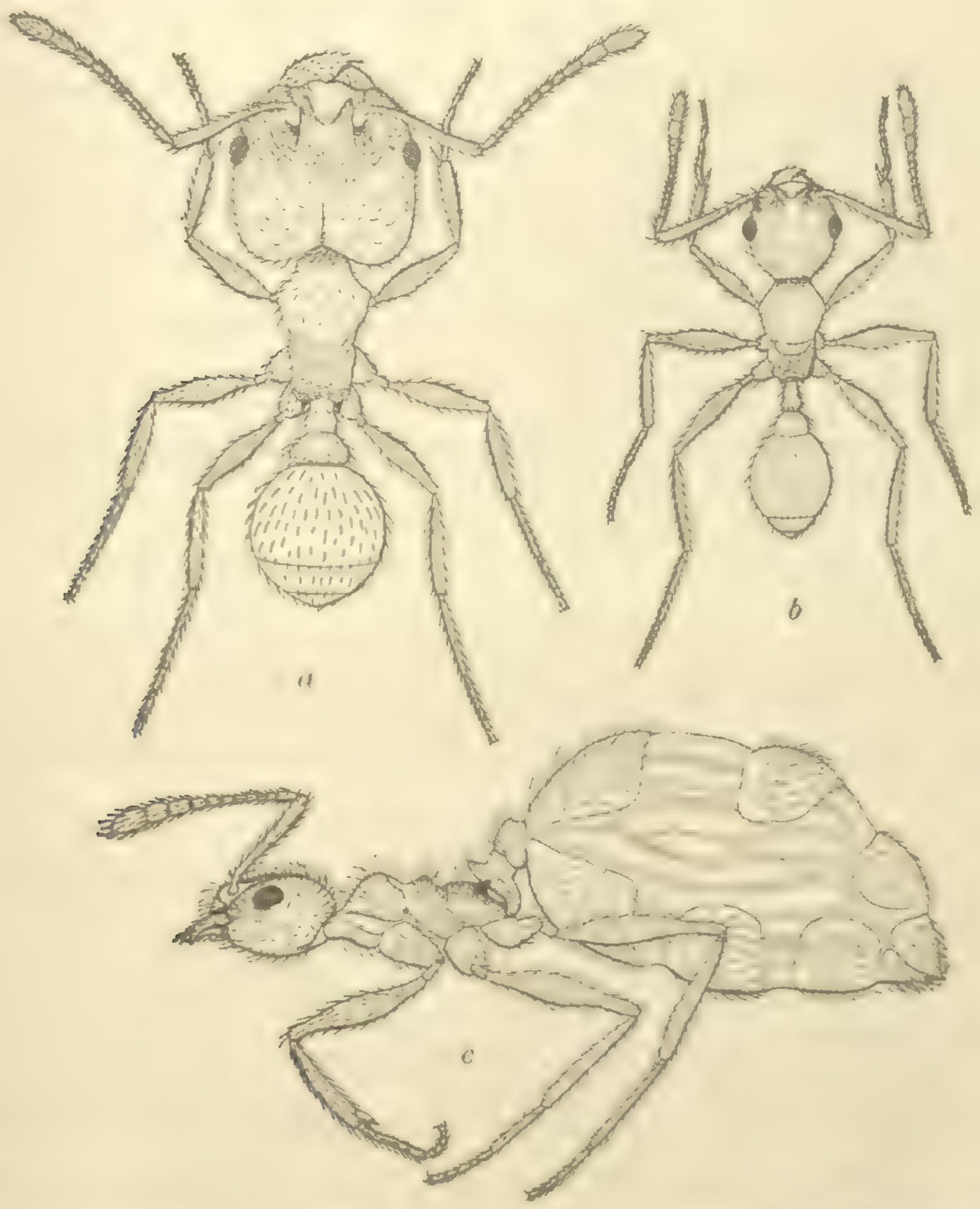
case the difference in size is not so striking on account of the enormous heads of the latter. The size relations are shown in the figures, which represent the soldier, normal and macroërgatic workers, drawn with the camera lucida under the same magnification.

Examination even with a good pocket lens reveals the cause of the great abdominal development of the macroërgates. One sees distinctly the white coils of a parasitic worm distending the abdomen till its dorsal and ventral sclerites are widely separated by the tense intersegmental membranes. Thus the abdomen of the Pheidole comes to resemble externally that of replete individuals of the honey ant (*Myrmecocystus melliger*) or our common northern *Prenolepis imparis*. In some of the alcoholic specimens the tense abdominal wall has burst and allowed a few of the coils of the parasite to protrude. Such specimens may perhaps suggest the way in which the parasite ultimately effects its escape from the ant, if indeed it ever leaves its host.

My friend, Dr. T. H. Montgomery, who has kindly examined a few of the Pheidoles, writes me that the parasite is a species of Mermis. Its exact location in the ant's body is not easy to determine, *i.e.*, whether it occupies the lumen of the enormously distended crop, or ingluvies, or lies in the body cavity outside of the alimentary tract. From careful dissection of a single large macroërgate — the one represented in the figure — I conclude that the Mermis lies *within* the ingluvies. In this case the head of the parasite extended forward through the postpetiolar and into the petiolar segment, thus occupying the attenuated neck of the ingluvies. The fat-body in the parasitized ants is almost or completely absent and the walls of the enormously distended crop are practically in contact with the walls of the abdomen. The large macroërgate figured contained only a single closely convoluted Mermis, which was fully 50 mm. long, or ten times the length of the ant. One individual dissected by Dr. Montgomery contained two somewhat smaller parasites, together with many of their eggs. According to Dr. Montgomery, the parasites are "either fully mature or

in what von Linstow calls the 'second larval stage,' which is, however, really the immature stage."[1]

While it is certainly somewhat singular that a species of Mermis should occur in ants, even greater interest attaches to the case under discussion on account of the manifest effects of the parasite on its host. The fact that all the infested individuals are of huge size as compared with the normal



Pheidole commutata Mayr. *a*, normal soldier; *b*, normal worker; *c*, parasitized macroërgate. (Drawn under the same magnification.)

workers is remarkable, for, on first thought, one would certainly expect an animal infested with such a large parasite to be stunted or, at any rate, below the average stature of the species. This paradoxical condition of the macroërgatic Pheidoles is easily understood, however, when we make due allowance for certain peculiarities in the behavior of ants. In the first place it is obvious that the parasites must enter the body

[1] Von Linstow, O. Das Genus Mermis, *Archiv. f. mikr. Anat.*, Bd. liii (1898).

of the worker ant while she is still a larva. This is proved by the fact that two of the large macroërgates are callows, one of them still very soft and pale yellow, the other — again the one represented in the figure — with harder integument, but without the deep coloration of the mature workers. Such huge parasites could scarcely have made their appearance in ants so recently escaped from their pupæ. But even if there had been no callows among the macroërgates, the truth of the above statement would still be patent, both because the macroërgates were all infested while none of the normal workers were found to contain parasites, and because the stature of an ant is, of course, fixed in the pupal stage and cannot be subsequently increased to the dimensions exhibited in the cases under consideration.

It is evident, furthermore, that the macroërgatic stature, which is very apparent not only in the distention of the abdomen but also in the greater dimensions of the head, thorax, petiole, antennæ, and legs, can have its origin only in an unusually large amount of food consumed during the growth period of larval life.[1] Now, as I have shown in former papers,[2] different species of ants employ very different methods of feeding their larvæ. Species of Camponotus, Formica, Lasius, and Myrmica feed their larvæ with liquid food regurgitated from their crops, and possibly also with the secretion of the salivary glands. Other species, however, like the Ponerinæ and some Myrmicinæ (Aphænogaster, Pogonomyrmex, Tomognathus, and some species of Pheidole), feed their larvæ with comminuted insects. Unfortunately I have not been able to observe the method of feeding in *Ph. commutata*, but it is safe to say that it must conform to one or both of these methods. If the larvæ are fed by regurgitation, we must suppose that the parasitized

[1] The opposite condition, *i.e.*, a small amount of food consumed during larval life, results in what may be called *microergatic* forms. Such are the firstborn workers of all incipient ant colonies. These forms are, of course, perfectly *normal* products of underfeeding, whereas the macroërgates of Pheidole are products of overfeeding induced by a *pathological* condition.

[2] Wheeler, W. M. A Study of Some Texan Ponerinæ, *Biol. Bull.*, vol. ii (1900), No. 1, pp. 1–31, Figs. 1–10; and The Habits of Ponera and Stigmatomma, *Biol. Bull.*, vol. ii (1900), No. 2, pp. 43–69, Figs. 1–5.

individuals have some means of informing their nurses that their appetite is unusually keen — like that of a human being infested with a tapeworm. If, on the other hand, the larvæ are fed with comminuted insects, they could simply of their own accord eat much more food than is consumed by the larvæ of normal workers. In either case, however, *the stimulus to the increased feeding that finally results in the macroërgatic stature must, of course, reside in the larva and not in the worker ants which supply the food.*

The ability of a small animal like the worker of *Ph. commutata* to nourish a parasite larger than the normal individuals of the host species is accounted for by the fact that the larvæ and adults of these social insects are so readily fed by other members of the colony. The infested ant therefore suffers relatively little inconvenience when compared with an animal which must rely entirely on its own efforts in securing food. Both during the larval and adult stages the macroërgate must be fed by the other ants, for it is extremely doubtful whether these heavy-bodied individuals ever leave the nest for the purpose of foraging. They probably remain at home like the heavy-headed soldiers.

It is not difficult to understand how the Pheidole larvæ become infested with the Mermis, since the parasite extrudes its eggs within the crop of the adult worker. Such eggs or the embryos arising from them could easily find their way into the gullet and mouth of the ant and be transferred thence to the larvæ while the latter are being licked and cleansed; or, in case the workers of *Ph. commutata* feed their larvæ by regurgitation, the transferring of the parasite would be still easier and more direct.

Other interesting conclusions follow from a consideration of the fact that all the macroërgates are structurally of the pure worker type. Except in the excessive size and peculiar hypertrophy of the abdomen, I can detect no morphological differences between the parasitized individuals and their diminutive sister ants. There is certainly no appreciable tendency to approach the soldier or female type of structure. From this we may conclude either that the larvæ must become infested with

the Mermis after they have developed as workers so far that their structure can no longer be affected except in volume, or that the still undifferentiated larvæ are infested but nevertheless develop into workers because so much of the food which they devour is appropriated by their parasites. A decision between these alternatives would require more precise study than was possible under the circumstances.

While there can be no doubt that macroërgatism in *Ph. commutata* is due to the presence of the Mermis, we cannot with certainty exclude the possibility of an atavistic tendency towards macroërgatism in the workers of this genus; for, as Emery has shown in a very suggestive paper,[1] in those ants which have the sterile females represented by huge soldiers and diminutive workers, the latter have without doubt undergone a reduction in size during phylogenetic development. It would be possible, therefore, to explain macroërgatism as an attempt to regain the ancestral worker stature which was, of course, that of the queen. This is probably the explanation of macroërgatism in many ants, *e.g.*, in Solenopsis, and possibly also in the small group of Pheidole mentioned in the introduction to this paper. While a similar reversional tendency may also be present in *Ph. commutata*, it is perhaps unnecessary to lay much stress upon it, since the presence of the Mermis is of itself quite sufficient to account for the stature of the macroërgates.

It is interesting in conclusion to compare the production of macroërgates in the nests of *Ph. commutata* with certain phenomena observed by Wasmann[2] in mixed nests of *Polyergus rufescens* and *Formica fusca*. He finds that such nests are peculiarly liable to contain ergatoid females of the former species, *i.e.*, "individuals which in size and in the development of the abdomen (even of the ovaries) belong to the true female type, but have the thoracic structure of the workers and are therefore wingless." From a biological point of view these are, as Wasmann claims, really secondary queens. He believes that they are produced by the slave ants (*F. fusca*) through

[1] Die Entstehung und Ausbildung des Arbeiterstandes bei den Ameisen, *Biol. Centralbl.*, Bd. xiv (1894), pp. 53–59. [2] *Loc. cit.*

excessive care and feeding of certain larvæ which had previously been permitted to develop as workers beyond the stage in which the wing rudiments would make their appearance in queen larvæ. In other words, the *fusca* workers attempt to change worker larvæ of Polyergus into queens but succeed only in producing the wingless ergatoids. In explanation of such conduct, Wasmann suggests that the *F. fusca* usually have several queens even in very small nests and may perhaps retain the instinct, when enslaved by Polyergus, to educate numerous female ants. If, after the nuptial flight of the Polyergus, they find no fertile queens of their own species in the nest they may endeavor to transform the young worker larvæ into queens with the above-mentioned result. Wasmann's hypothesis is of interest, as it points to the existence of a peculiar instinct in ants which regulates the number and character of the personnel in the colony. We know that such an instinct is well developed in termites, and it is more than probable that it exists also among ants. It offers an interesting field for future investigation.

Both Wasmann's hypothesis to account for the ergatoid females of Polyergus by excessive feeding of the worker larvæ, and his interesting "Lomechusa-Hemmungs-Hypothese," in which he accounts for the pseudogynes of Formica through an attempt on the part of the ants to transform queen larvæ into workers, seem to start from the assumption that the larvæ are quite passive and that the worker ants feed them entirely in obedience to certain instinctive promptings of their own. This accords with Emery's view [1] that the sexual polymorphism of the ant colony is the result of the development of an instinct in the workers to feed the larvæ in different ways. Hence, "the characters in which the worker differs from the corresponding sexual form are not congenital, or blastogenous, but acquired, *i.e.*, somatogenous. Nor are these characters transmitted by heredity, except as a peculiarity of the germ-plasma to enter on different paths of ontogenetic development according to the different circumstances of existence." While this view is undoubtedly supported by many facts, and while

[1] *Loc. cit.*

considerable importance may indeed be attributed to the initiative of the workers in determining the character of the adult ants which they rear, the macroërgates of *Ph. commutata* prove, nevertheless, that we must also attribute a certain amount of initiative to the larvæ themselves. If this be granted, it is but a short step to the admission that the initiative of the larva, even under normal circumstances, — *i.e.*, when not infested with internal parasites, — may be considerable. It is not altogether improbable that further investigation with this possibility in mind may lead to some alteration or emendation of the various hypotheses that have been framed for the purpose of explaining the complicated phenomena of sexual polymorphism. Thus we may find eventually that the tendency to develop abortive ovaries is really inherited (through the fertile queens of course), and that differences in the chemical nature of the internal secretions, perhaps analogous to those which are supposed to obtain between castrated and non-castrated animals, may furnish the different stimuli that induce the larvæ to demand of their own accord more or less food, or food of a different quality, and to develop accordingly into queens or workers.

COLEBROOK, CONN., August 10, 1901.

ON SOME POINTS IN THE ANATOMY OF A COLLECTION OF AXOLOTLS FROM COLORADO, AND A SPECIMEN FROM NORTH DAKOTA.

HENRY LESLIE OSBORN.

I. The Collection from Colorado.

In a previous article in this journal by the writer ('00) reference was made to a collection of axolotls which were kindly loaned by Dr. Lee for comparison with the specimen from Amenia, North Dakota, therein described. By an unfortunate mistake these specimens were located from Montana, but in fact they are from Colorado. The material was collected by Dr. Thomas G. Lee, of the University of Minnesota, during a brief stay in the mining town of Crede, in southern Colorado, during the latter part of August and the beginning of September, 1896. Having heard mention among the people there of "dogfish" and "fish with legs on 'em," he succeeded in locating the wonders in a lake twenty-five miles distant and paid the place a visit. He found the lake occupying a narrow valley hemmed in between two mountain ridges and dammed back by a natural formation, apparently of glacial origin, giving it much the appearance of an artificial lake. The elevation of the place is about eight thousand feet above the level of the sea. The water is very cold. The lake appeared to be very deep. At a distance of about a hundred feet from the shore a line one hundred feet in length would not reach the bottom. There were water plants growing abundantly in the lake, and among them there were areas that were free and open, in which the axolotls were seen coming up from time to time apparently to breathe. They were then captured with a dip-net. The larger sized ones were found farther out, while smaller ones were reached from the shore. Dr. Lee informs me further that he

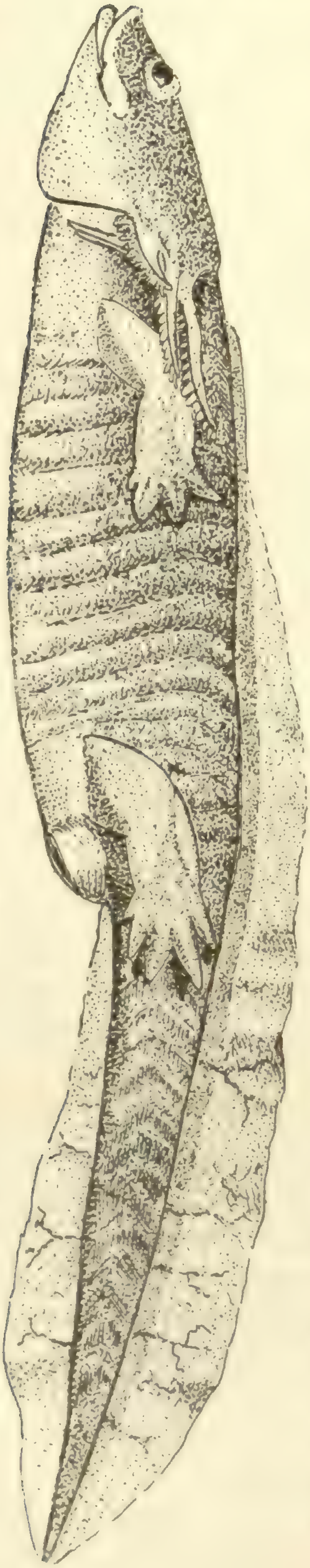


FIG. 1.—Side view of siredon from Colorado.

found the ordinary larvæ of *Amblystoma tigrinum* ranging in length from one to four inches in the irrigation ditches that were common in the San Luis valley in the vicinity of Garrison.

The material was preserved in 5% formalin. It contains in all twenty-six specimens, with the following lengths in millimeters, *viz.*: 89, 92, 98, 100, 103, 105, 105, 105, 106, 109, 110, 112, 113, 113, 115, 118, 118, 120, 121, 160, 190, 215, 220, 250, 250, 262.

Most of the specimens only corroborate the descriptions of previous writers as to the external characteristics of these interesting forms, and are mentioned here chiefly for the sake of making a record of the facts and the locality. One of them is in an advanced stage of metamorphosis, and has nearly reached the terrestrial form of *Amblystoma tigrinum*. This specimen is of especial interest, because it is in the act of undergoing its development in the midst of its natural surroundings. Marsh and Tegetmeier, as well as others, have described the metamorphosis of siredons under artificial conditions, but I do not know of an account of a siredon transforming in its natural environment. A number of measurements of these specimens were made, and are given in a table of measurements at the end of this article.

The external characteristics are indicated in Fig. 1, which is drawn from specimen No. 2 of the following lists. In the account which now follows, the siredon described as the type of the collection is No. 2. It will be compared with the other siredons, with No. 10, a metamorphosing specimen, and with adult specimens of *Amblystoma tigrinum* from the collection in the museum of Hamline University, from St. Paul, Minn.

The coloration (of the formalin material) is uniform and not mottled or spotted. The head and trunk are dark above and light beneath, the division line running from the jaw along the side of the head and on the body on the level of the ventral borders of the limbs. The post-abdomen, or "tail," is dark throughout, as are also the dorsal and ventral folds of skin, "fins." One of the larger specimens (No. 8) differs from the rest in being distinctly spotted. The spots are very numerous and small, about 1 mm. across, and are found in all parts of the dark area of the animal. Both of the Dakota specimens are spotted, as can be seen by a reference to Fig. 7 of this article and Fig. 1 of the preceding. In both of these, however, the spots are fewer and larger and more distinct. Baird's *S. gracilis* ('59 Vol. X, Pl. XLIV) is also spotted, and the Colorado specimen is more like to it, according to the illustration, than to the Dakota forms. In the smaller specimens of the Colorado collection the dorsal darker area is not uniform in tone, but is mottled with dark irregular patches scattered irregularly upon it. These patches are not distinctly bounded, but shade into the general color tone at the edges, and are very irregular in shape. They also extend out upon the dorsal and ventral fins.

The head in the Colorado specimens differs markedly from that of terrestrial amblystomas in several particulars. In order to afford the opportunity to test some of these points, I give a number of measurements made on specimens of Amblystoma found at Hamline, Minnesota. I may say that these are fully metamorphosed and strictly terrestrial.

By dividing the length of the head, from the snout to the fold crossing between the bases of the hinder gills, by the length from the chin to the posterior boundary of the cloacal

opening, we obtain the ratio of head length to head and body length, and can then make direct comparisons, irrespective of difference of length. By measuring to the cloaca we avoid the influence of the variation of the post-abdomen. These measurements and the ratio are shown in this table.

RATIO OF HEAD LENGTH TO LENGTH OF HEAD AND BODY.

COLORADO SPECIMENS									ST. PAUL AMBLYSTOMA			AMENIA SPECIMENS		
No.	Sizes	Ratio	No.	Sizes	Ratio	No.	Sizes	Ratio	No.	Sizes	Ratio	No.	Sizes	Ratio
12	$\frac{22}{60}$	37%	1	$\frac{34}{105}$	32%	10	$\frac{36}{135}$	27%	12	$\frac{23}{72}$	32%	×	$\frac{59}{192}$	31%
11	$\frac{23}{65}$	36%	6	$\frac{40}{130}$	31%				4	$\frac{22}{77}$	28%	KENMARE SPECIMENS		
5	$\frac{23}{63}$	33%	2	$\frac{36}{125}$	29%				8	$\frac{30}{105}$	28%			
3	$\frac{23}{68}$	34%	7	$\frac{39}{130}$	30%				5	$\frac{29}{109}$	26%	×	$\frac{41}{143}$	29%
8	$\frac{33}{90}$	37%	9	$\frac{39}{124}$	31%				10	$\frac{30}{109}$	27%			
			13	$\frac{43}{135}$	32%				7	$\frac{27}{110}$	24%			
Average 36%			Average 31%						Average 27.5%					

These figures show great variation in the head length in general among these forms, so that inferences from single cases will need to be carefully guarded. Thus in the first group we find ratios of 33% to 37%, and in the St. Paul forms we find a range of from 24% to 32%. The size variation thus shown to exist would be an interesting topic for study, and has not as yet been studied. Referring now to the ratios, we see clearly that on the whole the Colorado forms have a larger head than the St. Paul forms. In the latter the ratio is 27.5%, while in the former it is 31% for the larger sizes and 36% for the smaller ones. These figures are in reality an underestimate, for they are reduced by the fact that in the comparison no allowance has been made for the tendency of smaller specimens to have larger heads. This tendency is very well shown by comparing specimens of different sizes in the foregoing statement. Thus in the St. Paul specimens it is very clearly seen, and in the Colorado forms the smaller ones have a ratio of 36%, while the larger ones have a ratio of only 31%. If the series of specimens were large enough to enable us to eliminate

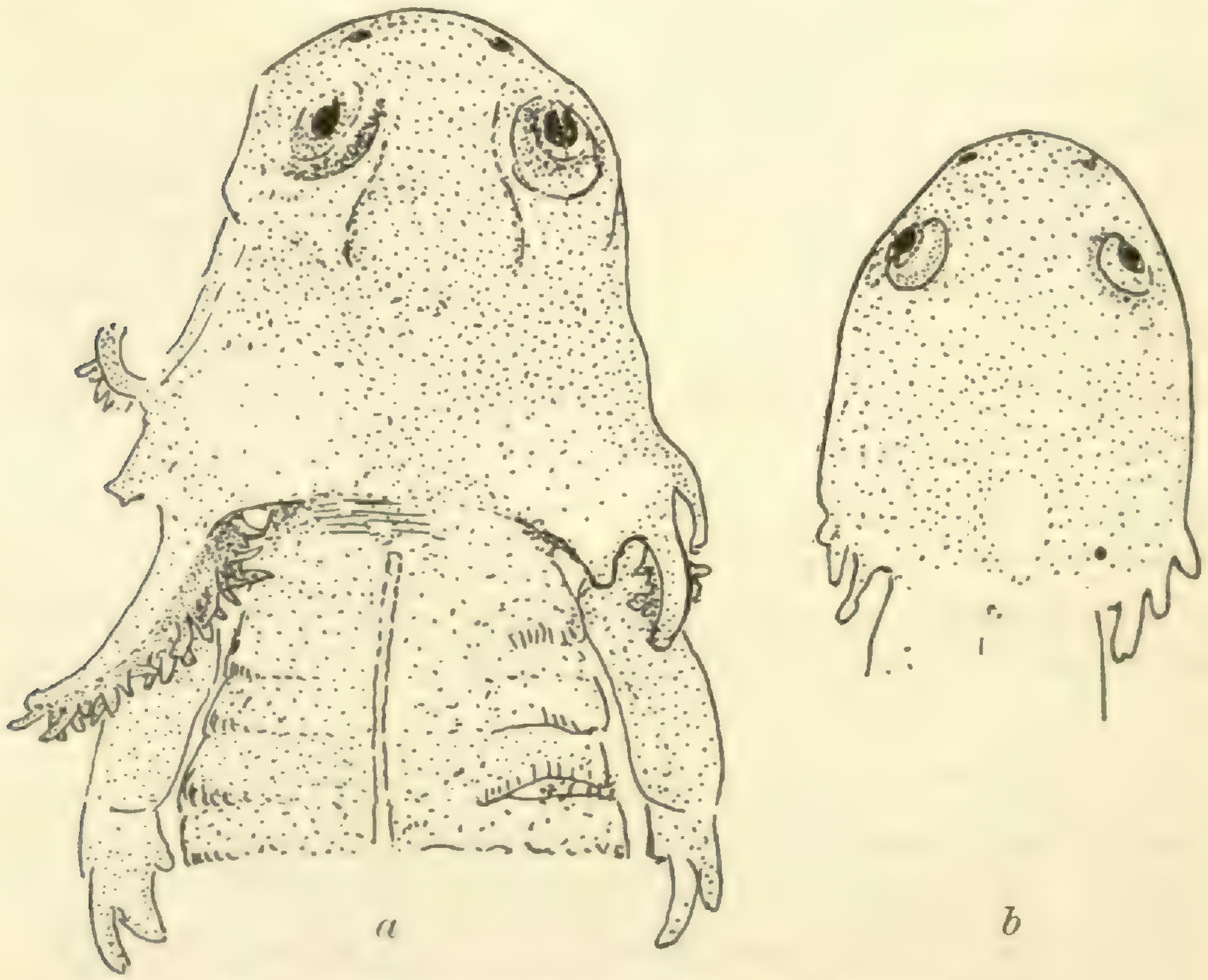
individual variation, a more accurate statement of the amount of difference could be made. But if we compare a Colorado specimen with a St. Paul specimen of the same size, we find in No. 1 of the Colorado forms a ratio of 32%, while Amblystoma, No. 8, of the same size has a ratio of 28%, and the larger St. Paul specimens have a still smaller ratio than even larger specimens of the Colorado series. Thus No. 7 from St. Paul has a ratio of 24%, while the largest of the Colorado series, a much larger animal, has a ratio of 32%. One should not, however, place much reliance on the comparison of individuals, but I believe that on large series of individuals of the same size it would be found that the head ratio in the siredons is much larger.

Not only is the head as a whole larger in the aquatic forms than in the terrestrial ones, but the proportion of its parts is also different. A reduction of the head in the throat region would be expected in connection with the degeneration of the branchial apparatus, and does occur. This is seen by reference to the following statement showing the lengths of these regions of the head in a number of different Colorado and other siredons and in six St. Paul amblystomas, *viz.*:

Colorado Series				St. Paul Series			
No.	Sizes	Snout to Eyes	Eyes to Neck	No.	Sizes	Snout to Eyes	Eyes to Neck
12	$\frac{6}{22}$	27%	73%	7	$\frac{11}{27}$	41%	59%
11	$\frac{6}{23}$	26%	74%	5	$\frac{12}{29}$	41%	59%
5	$\frac{6}{23}$	26%	74%	8	$\frac{12}{30}$	40%	60%
4	$\frac{6}{23}$	26%	74%	10	$\frac{12}{30}$	40%	60%
3	$\frac{8}{23}$	35%	65%	12	$\frac{8}{23}$	35%	65%
8	$\frac{10}{33}$	33%	67%	4	$\frac{9}{22}$	41%	59%
1	$\frac{9}{34}$	27%	73%	Average			60.3%
6	$\frac{10}{40}$	25%	75%				
2	$\frac{12}{36}$	33%	69%	Amenia Specimen			
7	$\frac{10}{39}$	26%	74%				
9	$\frac{9}{39}$	23%	77%	×	$\frac{13}{39}$	22%	78%
13	$\frac{12}{42}$	28%	72%				
Average			72%	Kenmare Specimen			
Metamorphosing Specimen				×	$\frac{11}{41}$	27%	73%
10	$\frac{10}{36}$	28%	72%				

These figures show that the average ratio of the length of the hinder part of the head to the front part is 72% in the siredons and only 60 in the terrestrial amblystomas.

The form of the outline of the head anteriorly is another point in which the aquatic and terrestrial forms differ considerably. The difference is shown in Fig. 2. In the former the outline of the head in front is very blunt and broadly convex; in the latter the outline bends suddenly after the



a *b*

FIG. 2. — Dorsal view of head of Colorado siredons, No. 2 and No. 10.

nostril is reached, producing a sharply convex curve. This is due to the presence in the aquatic form of a cheek fold of the skin bordering the jaws, not found in the terrestrial state. In the terrestrial forms the skin is drawn and tight-fitting over the whole of the head. This is obviously correlated with the need of providing against the desiccating influences of the atmosphere. In the aquatic forms, on the other hand, the skin is very loose and ample. This is noticeable generally in the head, not only in the general skin, but in the presence of gills, opercula, and such special modifications of the outer surface.

The folds at the side of the mouth reduce the diameter of its opening. This difference in the size of the mouth is another marked difference between the axolotls and the terrestrial forms. It is indicated in Fig. 3, where the angle of the jaws is seen in 3 *a* to be anterior to the eyes, while in 3 *c* it is considerably posterior. This smaller size of mouth is perhaps correlated with the processes involved in taking water into the mouth chamber for the purpose of forcing it back and out of the sides of the throat during aquatic respiration.

The gills (in No. 2) do not differ essentially from the accounts and figures of Baird and others. They are shorter than the head. They are flattened outgrowths of the sides of the throat. Proximally they are continued in the floor of the throat to the hyoid bone in the center. On the underside are the opercula, thin flaps of skin, which merge distally into the under margin of the gill. The gill plates are borne on the posterior side of the free portion of the gill, which by means of a muscle running its length can be drawn back against the side of the body, thus protecting the plates. The latter are thin and placed in rows crossing the long axis of the gill. They are so arranged that two longer plates next the edge of the gill are followed by two smaller plates, set nearer to each other in the middle, as shown in Fig. 4 *a*. Many of the specimens in the collection show the gills in a state of degeneration, the gills being much shorter and the plates reduced in number.

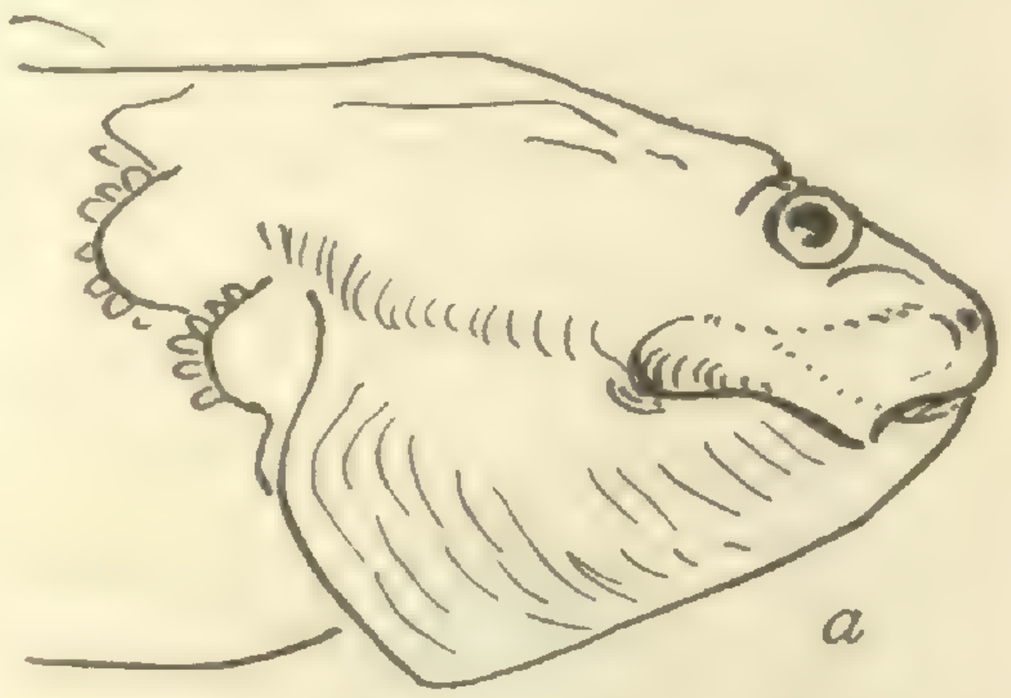


FIG. 3.—Side views of head. *a*, siredon No. 2 from Colorado; *b*, siredon No. 10 from Colorado; *c*, salamander from St. Paul.

The trunk is essentially the same in the siredon and terrestrial states, excepting as to three points, *viz.*, coloration, the dorsal fin, and the "webbing" of the toes. All of these changes have been commented on by previous writers, and may be passed without further notice.

The post-abdomen is acutely tapering from its origin to the tip. Its outline as a whole is very acute, unlike either of the Dakota specimens. It bears a very thin and membraneous "fin," which becomes noticeably wider posteriorly.

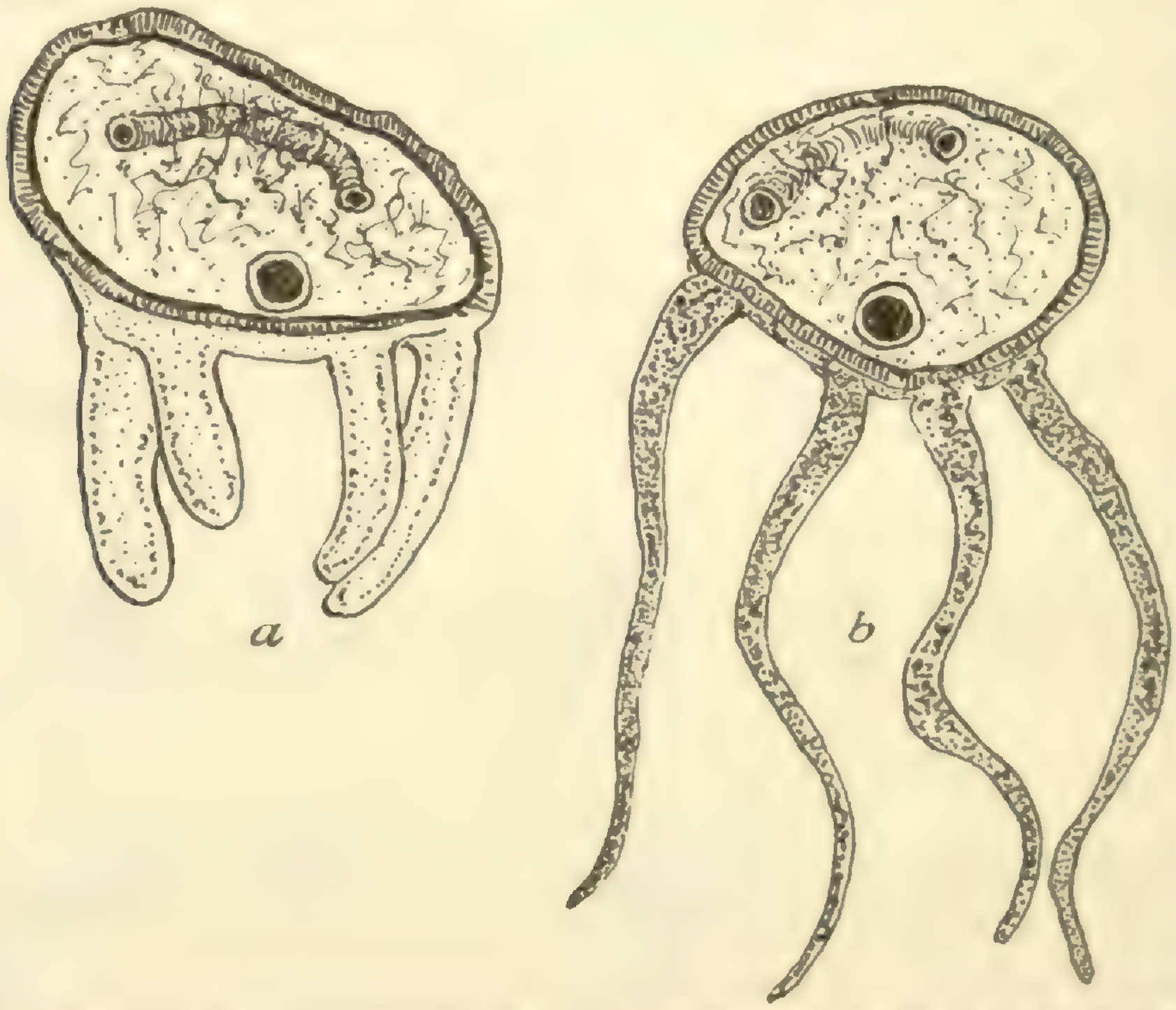


FIG. 4. — End view of gill, showing the gill plates. *a*, in Colorado forms; *b*, in Amenia specimen.

This broadening of the fin is greater than anything indicated in the figures of axolotls generally, and is quite different from the outlines in the two Dakota specimens.

The internal anatomy of the siredons, excepting of the mouth, is strictly the same as that of the mature terrestrial forms. A thorough dissection of one and a careful examination of several others of the collection demonstrated an anatomical condition of the viscera very similar to that indicated by Wiedersheim ('79) in his Fig. 1. The reproductive system in both the males and the females is fully matured, and in the females there are accumulations of eggs ready for discharge, and the albumen

glands are swollen and active. The heart and pulmonary organs have reached their final form, the former having two auricles and a connection with the lungs, and the latter consisting of the two elongate lungs communicating with the throat by means of a glottis. The siredon is thus morphologically a pulmonate or "air-breathing" animal, and so it is physiologically, for, notwithstanding its aquatic environment and branchial equipment, it uses its lungs for breathing.

A single one of the members of the Colorado series, the one numbered 10 in the list, is especially interesting, because it was taken in the act of transformation, the process nearly completed. The head of this specimen is shown in Figs. 2 *b*, 3 *b*, and 5. The general appearance of the animal is very similar to the one illustrated by Tegetmeier ('**70**). The head is intermediate in form between the aquatic and the terrestrial states. Its total length is 27% of that of the head and trunk. This is the ratio found in land salamanders, while 31–36 is that found in aquatic forms. The posterior part of the head, however, is here found not to be relatively shortened, as might at first be expected. It is 72% of that of the whole head, as in siredons, as against 60%, the ratio for land forms. As to outline in front, the head is as in the land forms, being strongly curved (see Fig. 2 *b*). The skin of the head is tightly drawn and not loose and abundant. This tension of the skin produces the bulging of the eyes noted by Marsh ('**68**) and Weismann ('**75**) among the changes of the transformation. Dorsally the head is arched, as in the land forms, and not any longer so flat as in the aquatic stage. The mouth opening is not yet as wide as it is in the definitive form. The fold at the angle of the jaws has lessened but not entirely disappeared, and the angle of the mouth is on the level of the eyes and not behind them (compare Figs. 3 *b* and 3 *c*). Ventrally the gular fold has become confluent with the floor of the mouth and throat in the center, and some distance from the middle line on each side the vestiges of the gill apparatus remain. The three clefts are still present on each side, but they have been pushed back and out from the throat, and are crowded into the small space left behind the gular fold (see Fig. 5). Structurally the apparatus is almost completely

aborted. Besides loss of length, the opercula are gone and the external parts of the gill are reduced to mere warty lumps. On the floor of the mouth the tongue had not yet developed. The trunk region is also intermediate and presents both siredon and salamander features. The coloration is still of the aquatic kind, showing no hint of the future dense black general tone spotted with irregular blotches of brilliant lemon yellow so characteristic of the land forms of the species. On the other hand, the dorsal fin is wholly absorbed, and the toes are no longer "webbed"; instead, the skin fits closely and the toe is cylindrical and tapering. With this change of the toes and the fins the power of locomotion by swimming in water must be very considerably diminished. The post-abdomen has also reached the final form, the tail fin being nearly completely absorbed.

FIG. 5. — Ventral view of the head and throat of siredon No. 10, showing the transition to the terrestrial form.

Tegetmeier reports in 1870 his observations upon a transforming axolotl. His account is very brief. He says: "The specimens were hatched in the summer of 1868, and kept under similar conditions without any change having taken place beyond steady increase of growth during the succeeding winter and the summer of 1869. In the autumn one began to change; the external gills disappeared, the jaws became more pointed, and the skin assumed a singularly mottled appearance. The animal did not leave the water, but when the temperature was warm usually breathed by standing erect against the side of the aquarium and elevating the nostrils above the surface; during the cold weather it usually remained submerged, rising at intervals to breathe." This case of Tegetmeier's seems to be like the Colorado specimen in that the metamorphosis took place while the animal still maintained its habits of aquatic life. Apparently the same may be said of the transformations reported on by Marsh ('68), Dumeril ('70), and Chauvin ('75).

We do not know the cause of the transformation of the siredon. In the St. Paul form of Amblystoma the animal first

becomes terrestrial and afterward matures. We have come to regard the land forms as mature, when as a matter of fact the aquatic form may be just as truly mature, since its organization, excepting in a few minor points, is identical with that of the land forms. There are two kinds of transformation distinguishable in the metamorphosis of an Amblystoma. One of these is in the development of the limbs, the alteration of the circulatory system, the development of the lungs, and the maturing of the organs of reproduction; these may be considered as the primary adult characteristics. In addition to these are a number of secondary changes, which do not involve radical morphological processes, but are largely confined to points in the external anatomy. These latter are secondary adult characteristics. The whole axolotl question turns on these secondary characteristics; for, as to the primary changes, they take place alike in axolotls, siredons, and salamanders, and one is as truly adult as the other. But for some reason an interval has arisen in axolotls and siredons between the primary and the secondary changes, so that instead of all of them progressing *pari passu*, the secondary changes are postponed, and take place either much later or not at all. In the neighborhood of St. Paul, amblystomas are fully adult when only 100 mm. in length, perhaps even less. In the Mexican axolotl, when the animal reaches this length, the secondary transformations do not take place, though the primary ones do, and the animal thus remains aquatic, though adult in all other respects. In the siredons we find that the condition is intermediate; instead of secondary transformation being indefinitely postponed and not taking place at all, it takes place much later. In specimen No. 10 it is taking place after the animal has reached a length of 235 mm. instead of having occurred at only 100 mm. In No. 2, of the same size and apparently from the same environment, it has not taken place, and no signs of its approach are visible.

FIG. 6.—Side view of the specimen from Kenmare, North Dakota.

II. THE SPECIMEN FROM KENMARE, NORTH DAKOTA.

The axolotl referred to in the former article (*American Naturalist*, July, 1900, p. 544) as having been found in Kenmare, North Dakota, has been kindly loaned to me for examination by its owner, Mr. W. H. Makee of Kenmare. It was somewhat injured by cutting in the throat, possibly when it was captured, and has been somewhat distorted by preservation in too small a bottle; still it is adequate for study and comparison with the Amenia specimen. As it had been preserved in alcohol, while the Amenia specimen was preserved in formalin, and as the Kenmare specimen was somewhat distorted in fitting it into its bottle, the measurements of the latter will not stand a rigid comparison with those of the other siredons.

Mr. Makee writes me as to the locality of the specimen, that it was caught among a number of fish in a seine during June, 1898, in Des Lacs Lake. The lake is thirty miles long and half a mile wide, and has an estimated depth of twenty-five feet. It is located in Ward County, North Dakota, and discharges through a chain of lakes into the Mouse River, a tributary of the Red River of the North, and finally of Hudson Bay. Kenmare is at

the opposite end of the state from Amenia, and is the most northern locality from which siredons have been reported. The coloration resembles the Amenia specimens and is unlike that of the forms from Colorado. It is dark above, excepting in a narrow tract on each side of the dorsal skin fold. There are numerous dark rounded distinct spots, the largest of which have a diameter of 4 mm. The spots are scattered over the body and post-abdomen and on the upper surface of the head. They are more numerous and larger than in the Amenia form. The undersides of the trunk and head are several shades lighter in color than is the case in the Amenia specimen. The skin is smooth, as in the Colorado specimens. The "coarse and warty roughness" of the Amenia form is not found in the Kenmare specimen.

The appearance of the Kenmare specimen is shown in Fig. 6. With the exception of its gills, it is more like the Amenia form than it is like the Colorado specimens. Its dimensions are shown in the table at the end of this article.

The head in the Kenmare specimen is shorter relatively to the length of the head and trunk than it is in the Colorado forms. This can be seen best by means of a table, thus:

Ratio of Head to Head and Trunk in

(*a*) the Kenmare specimen	29%
(*b*) the Amenia specimen	31%
(*c*) the Colorado specimens	34%
(*d*) the St. Paul specimens	27%

The injury of the head made it difficult to be sure of the length of head within 1% or 2% in the Kenmare specimen, but even so, the head is much shorter in both of the Dakota forms than in the Colorado specimens, and more nearly the length that is characteristic of the terrestrial forms. Too much stress should not, however, be laid on this fact, as the measurement is based on a single specimen in each case, and some of the single ones of the Colorado series have the head as short as 29%, as in this specimen.

The length of the head behind the eyes is also interesting here. Tabulating this measurement in the four cases, we find that the posterior length is

(*a*) in the Kenmare specimen 73%
(*b*) in the Amenia specimen 78%
(*c*) in the Colorado series 72%
(*d*) in the St. Paul series 61%

of the total length of the head. In this respect the Amenia specimen is very extreme, and the Kenmare specimen agrees with the rule for siredons, as determined by the Colorado series.

The head is also blunt anteriorly, as in general. The gular fold in the Colorado forms, as in siredons generally (see Baird, '52, Fig. 3), is emarginate, and this is the case in the Kenmare specimen, unlike the Amenia one.

The gills are three on each side. They are vertical outgrowths of the side of the throat, flattened so as to present a dorsal and a ventral margin; the latter, at the base of the gill, is continued inward under the branchial bone to form a thin flap, the operculum, which covers the gill slit in the floor of the throat (see Fig. 6). The gill presents two surfaces — one anterior, the other posterior. The former is naked, the latter bears the thin triangular plates in which the capillaries are placed which expose the blood to the aërating action of the water. The gills can be bent by the contraction of a muscle located within them, so that the posterior side is parallel to the body, and the gill plates are thus covered and protected.

There are four rows of gill plates. Two of the plates are larger and more external. They are on the same level, and are followed by two smaller and more internal plates. Each one of the plates is a tall triangular and flattened structure. At its base a blood vessel can be seen entering on one side. Capillaries filled with blood corpuscles can be seen in the interior, and running through the gill in the center and near the bases of the plate is a large vessel. The blood vessels are deeply pigmented, and the surface of the plates is minutely spotted with black branching chromatophores.

The gills differ from both the Colorado and the Amenia specimens. The lengths of the filament-bearing areas of three gills in succession, beginning with the anterior one, are respectively 76%, 90%, and 125% of the length of the head in the Kenmare specimen. The corresponding figures for the Amenia specimen are 76%, 90%, and 117%. For the Colorado forms they are, in case No. 21, 33%, 50%, and 72%. In both the Dakota specimens the gills are thus noticeably much longer than is the rule among siredons, as hitherto reported, and among the Colorado specimens which are in the main in accord with the cases reported by Baird, Marsh, and others. The gill in the Kenmare specimen does not broaden distally, but is tapering from base to tip. This is in contrast with the Amenia specimen, where the gills are spatulate in form, which point may, however, prove to be an abnormality. The form of the gill plates in the Kenmare specimen is different from either those from Colorado or the Amenia specimen. They are not long and filamentous as in the latter, and they are not short and blunt as in the former; but they are wide and plate-like, tapering to the tip, the outer row being longer than the inner; they are arranged as in the Colorado forms.

The body offers nothing for special comment. The coloration has already been mentioned, and the feet show the same broad foot margin of skin on the sides of the toes as is found in other siredons. The post-abdomen and the fin are much as in the Amenia form and decidedly unlike the siredons generally and the Colorado series. The body part is heavy and broad from base to tip; it is broadly convex at the tip, in marked contrast with the acute taper found in all the Colorado series. The fin is thick and strong, contrasting with the thin membranous texture of the Colorado forms, and it is not so wide as in them. In all of these points the post-abdomen is like that of the Amenia specimen.

An examination of the internal anatomy was made only in so far as it could be done by means of a short incision in the side wall of the body. Through this it was possible to see the lungs fully developed, as in a strictly terrestrial form, and the various viscera were similar to those found in the St. Paul material.

The sexual organs were not in an active state; a large *corpus adiposum* is present, and behind it a small elongate but not distended genital organ, which upon examination proved to be an ovary containing numerous slightly developed but recognizable eggs. I did not find any evidence to show whether the animal had ever laid eggs or was still immature, but the latter supposition seemed more likely.

BIOLOGICAL LABORATORY, HAMLINE UNIVERSITY,
ST. PAUL, MINN., April 18, 1901.

LITERATURE REFERRED TO.

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'59 BAIRD, S. F. *Rep. U. P. R. R. Survey.* Vol. x, Pl. XLIV.
'76 CHAUVIN, MARIE VON. *Zeitschr. f. wiss. Zool.* Bd. xxv.
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'70 TEGETMEIER. *Proc. Zoöl. Soc. London.*
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Table of Measurements.

Catalogue Number.	Colorado Specimens													Kenmare Specimen.	Amenia Specimen.	St. Paul Specimens of *Amblystoma tigrinum*					
	12.	11.	5.	4.	3.	8.	1.	6.	2.	7.	9.	10.	13.			7.	5.	8.	10.	12.	4.
Chin to tip of tail	108	108	113	123	120	155	190	206+	220	250	235	232	245	245	312	190	190	204	200?	125	125
Chin to margin of gular fold	16	17	16	17	19	25	24	30	27	30	28	29	32	30	35	26	23	26	27	18	17
Chin to post. edge of cloaca	60	62	63	69	68	90	105	130	125	130	124	135	135	143	192	110	109	105	109	72	77
Snout to level of bases of inner gills	22	23	23	23	23	33	34	40	36	39	39	36	43	41	59	27	29	30	30	23	22
Greatest diameter of head	18	19	20	19	21	27	31	35	38	38	33	31	34	38	55	21	21	23	22	15	15
Width of mouth	09	08	09	10	12	13	14	19	20	18	18	20	—	23	30	—	—	—	—	—	—
Distance between nostrils	06	06	06	06	06?	08	10	11	10	10	12	11	—	09	14	7	7	8	8	7	—
Distance between centers of eyes	11	11	11	10	12	14	16	20	18	20	18	18	—	20	26	15	14	17	15	11	11
Width of head at eyes	15	15	17	17	18	24	24	32	30	31	28	24	—	33	39	18	18	18	18	13	13
Snout to line joining centers of eyes	06	06	06	06	08	10	09	10	12	10	09	10	12	11	13	11	12	12	12	8	9
Length of filamentous border of gill 1	06	08	06	05	08	10	10	23	12	12	05	04	—	27	45						
Length of filamentous border of gill 2	06	08	06	05	12	09	10	15	18	12	05	04	—	42	53						
Length of filamentous border of gill 3	06	08	05	05	12	09	09	15	26	15	05	04	—	50	69						
Length of arm	06	07	06	07	07	12	15	15	12	15	14	13	—	19	24						
Length of fore-arm	06	05	05	07	07	09	11	15	11	12	13	13	—	17	17						
Length of hand	06	06	06	08	07	11	12	16	14	14	14	13	—	16	19						
Length of leg	06	06	08	09	07	12	12	15	13	15	14	15	—	14	19						
Length of fore-leg	06	06	07	07	07	09	12	15	13	13	14	15	—	15	19						
Length of foot	06	06	08	10	08	13	15	16	15	20	15	17	—	21	22						
Greatest height of tail	07	07	06	08	08	10	13	17	15	15	16	15	—	26	32						
Greatest thickness of tail	04	04	05	07	06	07	07	10	13	10	09	09	—	15	18						
Greatest height of dorsal fin	07	07	08	10	11	09	12	10	13	15	13	0	—	08	08						

A PARASITIC OR COMMENSAL OLIGOCHÆTE IN NEW ENGLAND.

M. A. WILLCOX.

Chætogaster limnæi von Baer appears to be the only oligochæte which is generally recognized as a parasite ; at least it is the only one to which Michaelsen in his recent work on the subclass (*Das Tierreich, Oligochæta,* 1900) ascribes such habits. The species has been reported only from Europe, and it is therefore with pleasure that I am able to announce the discovery in the neighborhood of Boston of a very similar form, regarding which I can at present give only the following incomplete notes.

The worms were first found about the end of May, 1901, infesting a species of Physa, probably *P. heterostropha*, which was obtained in a small stream in Wellesley. They were also afterward observed upon an undetermined species of Planorbis. They were abundant about the head and in the respiratory cavity. In a few instances the hinder part of the body seemed to be imbedded in the tissues of the snail, but of this I cannot be sure. Most of them certainly were entirely free, and, waving about like tiny white threads, had much the appearance of a fungus. Occasionally I have noticed them, like the European form, crawling over the outside of the shell ; but they ordinarily restrict themselves to the body of the snail.

This is undoubtedly the animal mentioned by Gould (*Report on the Invertebrate Animals of Massachusetts,* 1841, p. 213) under the name of *Gordius inquilinus* Müller, and supposed by him to be a parasite of *P. heterostropha*. In none of the specimens taken under ordinary conditions, however, did the alimentary tract give any indications of a parasitic habit ; on the contrary, I have seen in it no other food than diatoms. It will be remembered that Lankester in his description of the European form ("A Contribution to the Knowledge of the Lower Annelids," *Trans. Linn. Soc.*, Lond., Vol. XXVI.

pp. 631–646, 1870) speaks of finding the worms in winter within Limnæa, and gorged with the kidney cells, while he seems to have found no such evidence of parasitism at other seasons. I should add that in one instance, in which the worms had been left for some time in a watch glass with a torn Physa, the alimentary canal of almost every one was found stuffed with the blackish pigment characteristic of the snail, which was floating in the water.

The worm is a small, transparent animal, about 2 mm. in length and 1–5 mm. in breadth at its widest point. Both these measurements are taken in extension, but as the creature reproduces by fission, and as colonies of at least three persons are common, the first impression is of a much longer organism than I have described. On the ventral side, near the anterior end, are two clusters of cephalic setæ; each seta is sigmoid, about 1–14 mm. long, and ends in a fork whose prongs are equal and are bent nearly at right angles to the shaft; each cluster ordinarily contains seven setæ, though there may be six or, very rarely, five. In one case, one side bore the full number of seven, while there were but two on the other. It would seem probable that the remaining ones had been torn away. At some little distance behind these clusters are the abdominal ones, which differ from the former only in that the setæ are smaller (about 1–23 mm. in length), more numerous (being, as a rule, eleven, rarely ten, in a cluster), and borne on a slight projection of the body which apparently corresponds to a rudimentary parapodium. This last peculiarity, combined with a habit of holding the hind end fixed while extending and waving about the anterior one, gives the worm, as Lankester has already remarked, a curious likeness to a geometrid larva. There are sometimes as many as thirteen pairs of seta clusters behind the cephalic one; it is difficult to determine how many of these should be reckoned as belonging to a single individual, but for reasons which will be given in discussing the budding, I am inclined to consider with Lankester that the adult has four pairs of abdominal clusters.

The large mouth lies at the anterior end, but the dorsal edge projects rather over the ventral one, so that the tip of the body

in side view appears obliquely truncate. The mouth leads directly into the pharynx, which occupies rather more than one-third the length of the animal, is extremely distensible, and is connected by muscle bundles to the body wall. The pharynx is succeeded by an œsophagus so short and narrow as to be, when the other parts are greatly dilated, quite indistinguishable. Next comes the stomach, which as seen in optical section is nearly square and is separated by a constriction from the intestine. This division is somewhat longer than broad, and its walls are usually characterized by a yellowish brown hue, sometimes to be observed also on the stomach and suggesting the chloragogue cells of Lumbricus. Opposite the third abdominal setæ is a constriction, at which point this yellow color suddenly disappears. The remaining part of the intestine varies in shape according to the degree of development of the buds. The hind end of the worm is slightly notched.

The stomach is often found filled with diatoms, with which are likely to be intermingled a few pebbles. The other parts of the alimentary tract, if not entirely empty, are usually nearly so.

There are five septa: one opposite the anterior and one opposite the posterior end of the œsophagus; one at the constriction between stomach and intestine, one opposite the middle of the intestine, and one at the point of its posterior constriction. Behind the fourth abdominal setæ is a zone in which the cœlom may be absent, and behind this region may appear the cœlom of the bud.

The large blood trunks are a dorsal pulsatile and a ventral non-pulsatile one. They are connected by a pair of pulsatile vessels which encircle the œsophagus. Lankester has figured a pair of anterior ones extending obliquely down and back around the pharynx; I have seen such vessels, but am not sure of the way in which they connect (as they undoubtedly do) with the longitudinal ones. The blood is colorless.

Of segmental organs I have observed only three pairs; they appear as coiled granular organs in the last three segments. I have not found them in the segment which corresponds to the anterior abdominal setæ.

The nerve cord is a fibrous-looking band encircling the œsophagus and running back along the ventral wall. In the region underlying the pharynx the ventral cords, although close together and connected by several cross branches, are perfectly distinct ; this portion sometimes shows clearly in living specimens, and I have remarked in it no ganglionic swellings. In a stained and mounted specimen, however, when seen in profile, two ganglia are clear and there are traces of a third.

Upon the reproductive system I have made no observations. The worms at the season at which I examined them appeared to have these organs undeveloped.

Every animal examined was in process of active budding. A comparison of different stages indicates that this process takes place in the following way. The first part to be formed is what I may call the abdominal portion ; that part, namely, which bears the abdominal seta clusters and which consists in the adult of four segments. These segments arise by terminal budding from the parent ; when two of them have been formed so that there is a series of six in all, there arises between the third and fourth a zone in the anterior part of which is differentiated a terminal segment, the fourth segment of the parent, while its posterior part is converted into the anterior part of the bud. During this process of differentiation another segment has arisen at the terminal end of the chain, so that when its anterior end is complete, the bud has four abdominal segments. Before it breaks away from the parent, however, a new individual has begun to develop between the two.

The series upon which these conclusions are based consists of the following stages : *a*, a terminal bud just ready to break away, and possessing four abdominal segments ; *b*, an older individual with five abdominal segments, the fifth one the youngest, as shown by its size and by the number and development of its setæ ; *c*, one with six abdominal segments present, but a zone as yet undifferentiated into segments between segments 3 and 4 ; *d*, a similar specimen, except that a seventh segment has been added at the hind end of the chain ; *e*, a specimen like *d*, except that two pairs of seta clusters are developing in the hitherto undifferentiated space between segments

3 and 4 ; *f*, one like *e*, but with a deep groove formed between the two sets of developing setæ.

Before the bud breaks away from the parent, a new individual has begun to develop between the two. In my experience, which has extended over only a single month, it has been rare to find a chain consisting of more than three persons, and as in such chains the older bud is often so far developed as to be readily detached from the rest by the pressure of the cover, I am inclined to doubt whether colonies of as many as sixteen zoöids (*cf.* Claus, *Würzburger naturwissenschaftliche Zeitschrift*, Bd. I, pp. 37–40, 1860) are ever found in our form.

Upon comparing this description with that given by Lankester for the European form, it will be seen that the only important difference which has been shown to exist relates to the number and arrangement of the setæ in the different bundles. I am uncertain how much importance should be attached to this difference. Lankester describes his species as having twelve setæ in the cephalic bundles and eight in the abdominal ones, and after having for more than three years "taken every opportunity of examining the little worms" states that this number is "almost invariable" (*Quart. Journ. Micr. Sci.*, N.S., Vol. IX, pp. 272, 276). Vejdovsky, on the other hand (*System und Morphol. d. Oligochaeten*, p. 36), in describing the same species, says : "Bezüglich der Anzahl der Borsten variieren die Bündel bedeutend, indem man auf den hinteren Segmenten gewöhnlich eine grössere Menge derselben vorfindet als in den vorderen Borstenbündeln. Im allgemeinen trifft man in einzelnen Bündeln, 8, 9, 10, 10–12 Borsten." I have not, however, in an incomplete but somewhat careful review of the literature, been able to find published authority for this statement of Vejdovsky.

In view of this uncertainty and of the fact that Lankester's paper, which contains the only full anatomical description of the European species, is somewhat difficult of access, it has seemed worth while to give a fairly full account of our own form. Lankester's plates are so complete and so admirable that it has not seemed desirable to add illustrations to this description.

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OBSERVATIONS ON THE BREEDING HABITS OF AMEIURUS NEBULOSUS.

ALBERT C. EYCLESHYMER.

ALTHOUGH the bullhead, or horned pout, is one of the most common of our fishes, but little was known of its breeding habits until Professor Birge, several years since, discovered the nests and eggs and made some interesting observations on the behavior of the fishes during the spawning period. The earlier naturalists had given us hints as to the breeding time, but these suggestions were little more than indefinite surmises, partaking of the character of the following remarks by Thoreau: "The horned pout are dull and blundering fellows, fond of the mud, and growing best in weedy ponds and rivers without current. They stay near the bottom, moving slowly about with their barbels widely spread, watching for anything eatable. They will take any kind of bait, from an angleworm to a piece of tin tomato-can, without coquetry, and they seldom fail to swallow the hook. They are very tenacious of life, 'opening and shutting their mouths for half an hour after their heads have been cut off.' They spawn in spring, and the old fishes lead the young in great schools near the shore, seemingly caring for them as the hen for her chickens. A bloodthirsty and bullying set of rangers, with ever a lance in rest, and ready to do battle with their nearest neighbor."

While the observations made by Professor Birge have never been published, some of the facts have been given me in a private letter, from which I have permission to quote. Professor Birge writes: "The bullheads on which I made my observations made their nests in a shallow bay with sandy bottom, in water not more than two feet in depth. Some of the nests were in water not six inches in depth; hardly deep enough to cover the male while sitting on the eggs. This bay was overflowed land and contained numerous stumps, which had become hollow in the

course of time, and perhaps three of the nests were in these stumps, to which access was easily gained by the spaces between the roots. The others were among weeds and differed considerably. One or two bullheads kept the weeds away from the eggs, so that it was not difficult to see the nest from the shore, while others were concealed so that it was almost impossible to see the eggs or fish without removing the weeds from above them.

"There was a surprising difference in the disposition of the fishes on various nests. One of them was extremely tame. If approached cautiously he would not swim off, and it was quite easy for me to put my hand under him and lift him off the nest. He seemed to enjoy being scratched gently, and when lifted off the eggs would remain where placed or would swim off a short distance, and, in general, was very little disturbed by handling. Others were exceedingly shy, so that as soon as one had approached within a few yards of them they would dart off, throwing the eggs out of the nest as they went, with a jerk of the tail. Of course they always came back and brought the eggs together again. But this violent treatment of the bunch of eggs was apt to break it up, and I observed that a considerable portion of the eggs was lost in such cases. One of the catfish, whose eggs were in a stump, was particularly ferocious, and this was the only one which I found that had a violent disposition. I found the nest and put my hand down into the stump to take some of the eggs, when the fish seized it and worried it with all his force. After that, I found it necessary to remove the eggs from this nest with a pair of long forceps, which the fish would bite in spite of being rapped on the nose with them rather vigorously. It was this difference in disposition that especially attracted my attention in studying the catfish."

In June, 1892, I secured a number of bullheads from the small ponds in the vicinity of Worcester, Mass. Some of these contained ripe ova and sperm, and an attempt was made to artificially fertilize the eggs, but with ungratifying results. Many eggs passed through the cleavage stages, but all perished before the embryos were discernible. Although repeated efforts were

made to find the nests, they were unsuccessful until June 8, 1896, when three nests were found in Fowler Lake, Wis. Two of these were in pieces of stovepipe, the third in an old pail. The nests were in clear water, near a bold, rocky shore, and at a depth of four or five feet; all contained embryos, and each was guarded by a parent fish, — which one I did not ascertain. On the following day, in searching for other nests, I raised a small piece of tin pipe and was surprised to find a pair within. Through the raising of the pipe they became so wedged that it was impossible for either to get free. They had not yet begun spawning, although the eggs were so ripe that they were easily extruded by slight pressure. Artificial fertilization was again tried, but was only partially successful. A small percentage of the eggs segmented, most of which died before the embryos appeared.

During the month of June, 1898, I chanced to camp near Mud Lake, Mich., and learned from the fishermen that the lake abounded in large bullheads. An extended search was made on June 9, 10, and 11, and we had almost given up the search when one of my companions found a nest in a small bay with shallow, sandy shoals. Soon a dozen or more were found along this sandy shoal, and in a depth of water not exceeding three or four inches. They were usually concealed beneath logs, stumps, or boards, which lay against the bank. One would often observe a slight depression, and upon turning the sheltering object would find the pair engaged in spawning or watching over the freshly laid eggs. In two nests which were found beneath logs on June 11, the parent fishes were moving about in the small sheltered excavation. The eggs were removed in each case; those of one lot were in early cleavage, while those in the other were in late gastrula. Both nests were visited on the following day, but the fishes were no longer present. Another nest, in which the eggs were in late gastrulation stages, was uncovered and left exposed. When visited on the next morning neither fish nor eggs were found. I suspect that the eggs are devoured by the parent fish when the nests are too much disturbed, as is known to be the case with some of the Amphibia. I have, on several occasions, found eggs in

the stomach of Necturus. In one instance I partially removed the eggs from a nest, and upon returning the next day found the old Necturus in the nest as usual, but the remaining eggs could not be found. The parent was taken, and an examination revealed the fact that a number of eggs had been swallowed.

It was interesting to watch the actions of the fish when the sheltering object was removed. A fence rail covering a nesting pair was carefully turned, when the fishes immediately sought its shelter. As it was turned farther and farther from the nest they followed, keeping as well secluded as possible, the while moving restlessly about in search of the nest. When the rail was finally lifted from the water the male lingered for a few moments, then darted for deeper water. The female approached the shore and began searching here and there for her lost nest. This she passed several times without recognition, although she seemed to know the surrounding landmarks, since she would go but a short distance in either direction, then turning would pass back to the locality of the nest, which she found in a short time, and despite the fact that it was unsheltered, she remained. On the following morning the nest was visited, but again neither fish nor eggs were to be found.

It is not difficult to allure the fish to an improvised shelter. A number of boards were placed on the shore with one end projecting into the shallow water. The fishes sought these places and made their nests beneath the boards. It is worthy of note that in no case did I observe more than a single nest beneath the same cover, and this quite agrees with the pugnacious character of the fish.

Two nests which were occupied by both parent fishes were left undisturbed and when visited two days later only one fish was present. It was found by examination that in each case it was the male. When the female leaves the nest could not be definitely determined; as nearly as could be ascertained it would seem to be about the time the embryos begin to move.

The eggs are laid in masses, quite unlike those of most fishes, but similar in general form to the egg masses of the common frog. They are free from pigment and present when beneath

water a rich creamy color. The period intervening between deposition and the beginning of cleavage is not precisely known. After cleavage has begun it continues rhythmically as long as it can be followed, the intervals between successive cleavages being about thirty minutes. In forty to fifty hours after the beginning of cleavage the embryo is plainly visible, measuring 2 mm. to 2.5 mm. The larvæ at the time of hatching are about a week old and measure 7 mm. to 8 mm. When they break through their surrounding envelopes they are quite unable to support the load of food yolk, but lie on their sides, now and then making a few vigorous movements. In the course of a few days they are able to swim about and soon leave the nest accompanied by the male fish.

During the early summer of 1899 I was able to make some further observations on the habits of the larvæ. In one of the drainage ditches on Cottage Grove Ave., Chicago, they were so numerous that in walking a distance of a hundred yards one would see from seventy to eighty schools. The larvæ are usually huddled so closely together that they form a dark mass, which at a distance appears as a shadow moving to and fro. They rarely move in straight paths, but are ever circling, apparently in quest of food. When they come in contact with aquatic plants they pause, carefully search over the leaves, and again join in a common movement for other grounds. Frequently one departs from the company and darts here or there after an insect which may be passing along the surface of the water. One never observes them at rest, as is common for the adult. During the night they seem to be especially active, since it is during this time that they jump over the edges of the hatching dishes.

The broods vary widely in numbers; one occasionally observes a group of forty or fifty and again one containing several hundred. It was at first thought that either the number of eggs deposited by the different fishes varied accordingly, or that a much greater percentage survived in some cases. While both these factors probably modify the numbers, the chief cause of these wide variations was discovered one day when I chanced to observe four good-sized groups of larvæ

approaching a common point. I awaited with interest their movements and was surprised to see them unite to form a single school, which, however, remained intact but a short time. The larvæ soon separated into three groups, each of which pursued a different course. This procedure was repeatedly witnessed, sometimes the union of small groups to form a large one, again the subdivision of a large one. The fact that the larvæ in some of the broods vary widely in size is thus easily explained. A slight disturbance of the water is sufficient to disperse them, after which they again join in a closely aggregated group. A shadow cast upon the water and quickly removed sends them scurrying here and there. I was quite surprised to discover that a low guttural sound caused them to disperse, while a shrill whistle caused no commotion.

During the summer of 1900 I was able to make some observations on the behavior of the fish preceding the spawning. While observing the habits of the black bass in the artificial ponds of Oakwoods Cemetery, Chicago, I saw a number of large bullheads swimming about singly and close to the shore. I thought at first that they, like many of the other fishes in the lagoons, were exceedingly tame and had sought the shallow water for the purpose of obtaining food. After several ineffectual attempts to induce them to take worms, bits of meat, bread crumbs, etc., I concluded that they were not feeding, and since from previous observations I knew this to be their spawning time I surmised that they might be searching the shore to locate suitable nesting places. They would frequently swim so far into the shallow water that the dorsal fin and upper portion of the body were above the surface of the water. Here they would wriggle about, and if an indentation or slight excavation were found they would pass in, move rapidly about, swim out and on, only to repeat the procedure when another suitable locality was found. The fishes were always single; in no case were two observed even in close proximity.

On May 15 and 18 increasing numbers of these wanderers were observed. On May 20 I was gratified to witness what seemed to me a natural sequence. A cloud of muddy water attracted my attention, and walking cautiously to within a few

feet of the spot I waited until the turbidity cleared, when I saw a large bullhead lying motionless on the bottom and at a depth of eight to ten inches. After a period of some five minutes she swam close to the shore, placed her head in a slight excavation, and with a violent action of the entire body threw up another cloud of mud. When the water again cleared she was observed a short distance from the excavation. At short intervals the process was repeated. The excavation was being made in soft clean sand and beneath the sod bank which formed the shore of the lagoon. I had watched the movements of the fish for a half-hour or more when a second fish appeared and at once began to excavate in a manner similar to that noted for the former, the first fish meanwhile lying motionless a few feet away. Although both fishes were pretty well covered with sand, a number of differences were observed. The latter was much darker than the former, the abdomen a brighter yellow with less protruding abdominal walls, and although about the same size, I concluded that the latter was the male and that they had mated. While the excavating was now done by one, now by the other, it seemed that the female took the more active part. After watching the actions of the pair for an hour or more I retired and did not again visit the nest until the morning of the following day, when both fishes were again observed at work in the same manner as on the preceding day. The excavation was now deep enough to almost entirely hide the fishes, the tips of their tails barely showing. The nest had been greatly enlarged, as was evidenced by the quantity of sand which had been thrown out and which now covered an area of about three or four square feet, with a maximum depth of four or five inches. The top of this little mound was hollowed out into a deep, saucer-like depression from which a broad groove led to the nest.

On the next morning there were further indications that the excavating had been continued, but no evidence of its being still in progress. The female was at this time observed lying in the saucer-like depression, from which she soon departed. After considerable jarring over the nest the male was frightened out. I was not permitted to disturb the bank of the lagoon,

and consequently was not able to make observations on the interior of the nest; by reaching back in the hole a distance of sixteen to eighteen inches I could feel the egg mass, and upon the removal of a portion of the eggs found them to be in late cleavage stages, and from previous observations inferred that they could not be more than twelve hours old.

The above fragmentary notes embody, so far as I am aware, the first published observations on the behavior of the bullhead during the breeding period. They are recorded with the feeling that they may be of service to those who have so long sought the embryological material of this primitive teleost. I may further remark that a study of the breeding habits under natural conditions shows that Ameiurus rarely burrows in nesting, but instead seeks concealed places beneath logs, stumps, boards, or even pails or other receptacles which are easy of access. If, however, a modified environment replaces the natural, and the places for concealment be no longer present, as in the artificial ponds, we find the fish adapting themselves to this changed condition and constructing nests which often require two or even three days of unceasing labor to prepare.

In closing I cannot refrain from suggesting that a more extended series of observations would doubtless show that other fishes, like Ameiurus, manifest an entirely different behavior during the spawning period as a direct adaptation to the changed environmental conditions. Indeed, my observations on the dogfish (Amia) and the black bass living in the artificial ponds indicate that this is true of these forms as well.

UNIVERSITY OF CHICAGO.

THE SPERMATOGENESIS OF ONISCUS ASELLUS LINN., WITH ESPECIAL REFERENCE TO THE HISTORY OF THE CHROMATIN.

M. LOUISE NICHOLS.

This study was begun in February, 1899, and finished in January, 1901. Its more important results are described in this paper. A more complete and detailed account of the spermatogenesis will appear in a later publication.

I. Structure of the Testis.

Each one of the two testes consists of three narrow lobes, distinct from one another and opening successively into the anterior expanded portion of the vas deferens. The interior of each lobe or follicle is occupied by the germ cells, which are in differing stages of development in the three follicles of one side. Each follicle may be divided into two principal regions of growth, composed of cells of different generations and of differing degrees of development. The illustration (Fig. 1) will make this clear.[1] It shows, in a typical case, the comparative degrees of development to which the cells of the three follicles have attained. Thus, in the most posterior of the

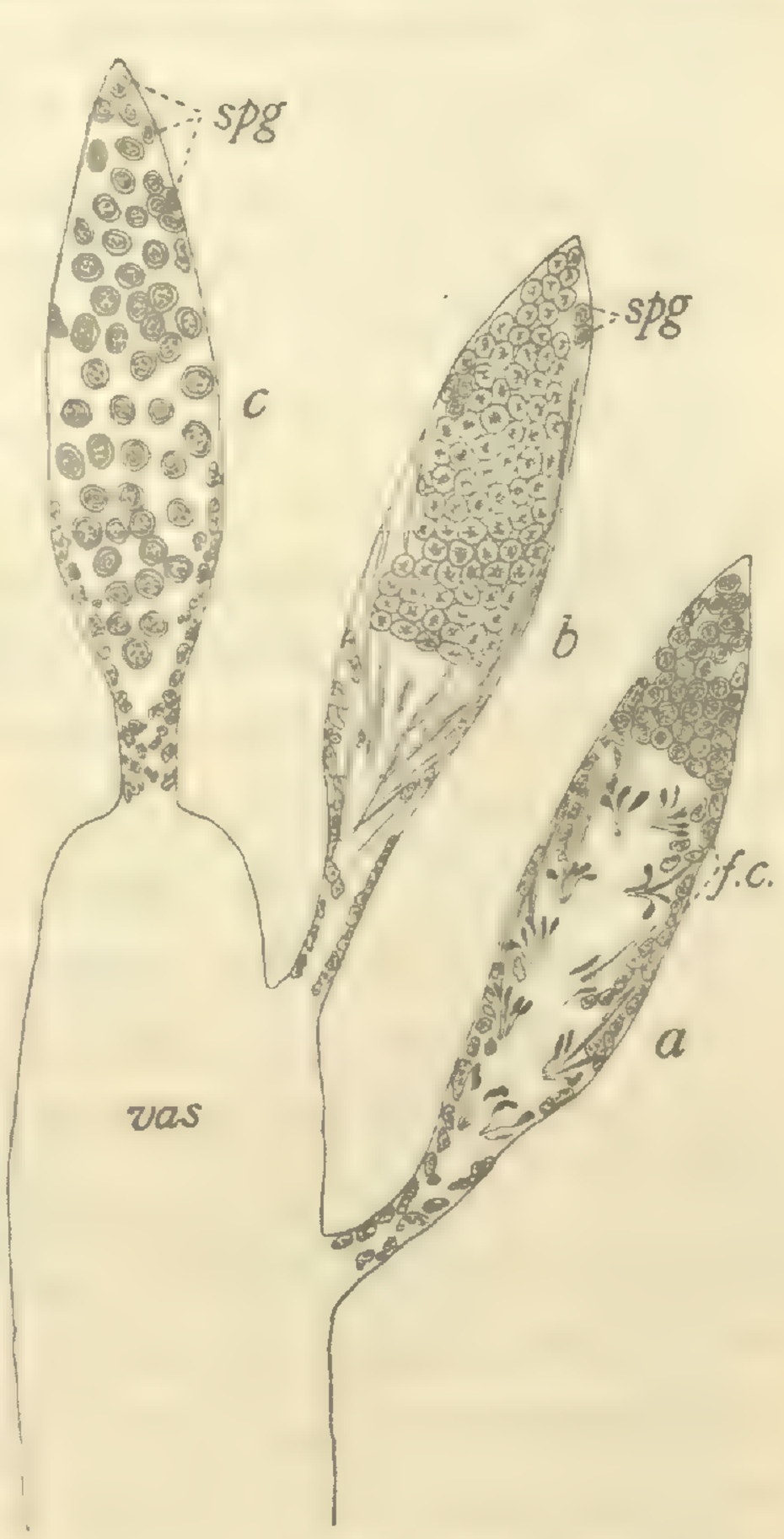

Fig. 1. — Testis of *Oniscus asellus* Linn. *a*, *b*, *c*, follicles of testis; *vas*, anterior part of vas deferens; *f.c.*, follicle cells; *spg*, spermatogonia.

[1] This and the following figures are slightly schematic.

follicles (*a*) the apical third is occupied exclusively by spermatogonia, some of which can be seen in mitosis ; the basal region, on the other hand, by spermatids in an immature state. Follicle cells occur on the outside of the follicle, being especially abundant in the basal region. In the adjacent follicle (*b*) the apical two-thirds is occupied by cells in the synapsis stage, the remaining portion by spermatids in a stage of development later than that of follicle (*a*). Along the margin of the follicle are found scattered small groups of spermatogonia (*spg*). The third and most anterior follicle (*c*) contains chiefly spermatocytes in a late prophase. Groups of spermatogonia similar to those of follicle (*b*) are here also found scattered along the margin and nearly filling the extreme apical portion. The follicle cells in the basal region are undergoing not only active amitotic division, but to a certain extent degeneration. Their active multiplication or fragmentation causes them to crowd in towards the axis of the follicle.

From a comparison of the extent of these growth regions in the three follicles, the developmental cycle may be conceived somewhat as follows. The spermatozoa, when fully formed, are forced into the vas. Since they have no motion of their own, this is probably caused by the contraction of the muscle layer of the follicle, perhaps assisted by the pressure of the growing cells in the apical region. During this process the spermatogonia in the apical portion of the follicle divide and come to fill up the space left vacant by the discharged sperm. The majority of the spermatogonia thus filling up the follicle proceed in their development, while the remainder form the groups of cells along the margin of the follicle already described in follicles (*b*) and (*c*), and which are destined to supply a new generation of cells. The spermatids also proceed in development and are forced into the vas.

A condition like that represented in follicle (*b*) thus arises, the basal region filled with spermatozoa in a late stage about to pass into the vas deferens, and the apical region with cells which have progressed as far as the synapsis stage. Later, the spermatozoa having been completely discharged, the cells of the apical region come to occupy the basal part of the follicle,

being now less compactly pressed together (*c*). Their development progresses until, having become mature spermatozoa, they pass into the vas deferens ; the spermatogonia again fill the apical region and the cycle is repeated.

II. Spermatogenesis.

1. *Maturation.*

The chief feature of interest in the history of the chromatin lies in the fact that the first maturation division separates univalent chromosomes and is therefore reducing.

This can be demonstrated by following the changes in the chromosomes from the synapsis stage through the first maturation division. In the anaphase of the last spermatogonic division the chromatin threads lie massed together near the center of the cell so as to be almost indistinguishable from each other. They gradually spread apart and are seen to be for the most part V-shaped (Fig. 2 *a*). There follows an elongation of the threads, and during this process the granules of which they are composed divide into two, so that each chromosome becomes longitudinally split (Fig. 2 *b*). Of the entire number of chromosomes present it is difficult to be certain, owing to the fact that they overlie each other so closely. The number, however, is certainly less than that present in the spermatogonia and not greater than sixteen. The reduction in the number of the chromosomes apparently takes place, therefore, at this stage, and the V-shape so prevalent is due to the approximation of two of the spermatogonic chromosomes to form a bivalent one. The threads become more and more attenuated, and finally by anastomosis are transformed into the nuclear reticulum of the resting spermatocyte. The fact that the chromosomes remain distinct until just before the formation of the nuclear membrane points to a maintenance of their individuality in the resting cell. In preparing for the first maturation division, the meshes of the nuclear network become coarser, the granules

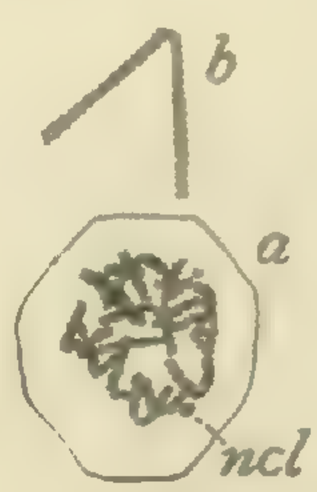

Fig. 2.—*a*, cell in the synapsis stage. *b*, bivalent chromosome at a later period of the synapsis, showing the longitudinal splitting of the chromatin granules ; *ncl*, nucleolus.

more distinct and aggregated into separate threads joined together by linin. The manner of their origin again lends support to the view concerning their individuality in the resting cell. By a gradual process of condensation sixteen compact masses of chromatin are produced. These sixteen masses are of various forms. Some are dumb-bell-shaped, two spheres of chromatin joined together by linin; some are crescent-shaped, and still others are more or less complete rings (Fig. 3). The different forms may occur in the same nucleus, but apparently without constancy in the ratio of relative frequency of occurrence.

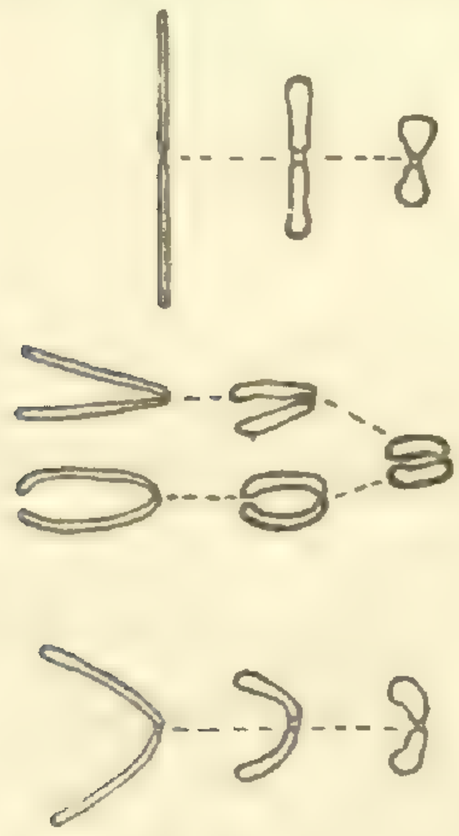

Fig. 3. — Mode of formation of the bivalent spermatocytic chromosomes (diagrammatic).

Two main types may be distinguished among the chromosomes according to their structure and mode of origin; *i.e.*, (1) those in which the bivalent chromosome consists of two univalent chromosomes lying end to end, as in those having the dumb-bell shape; and (2) those in which the univalent chromosomes lie side by side, as in those arising through a ring or narrow V-shape. A form intermediate between these is represented by those having a crescent shape. The different types and their probable mode of origin are shown in the diagram (Fig. 3).

In the equatorial plate of the first maturation division the two forms may again be seen. In sections stained with iron hæmatoxylin and strongly decolorized a longitudinal split is distinguishable in the chromosomes. In the dumb-bell-shaped chromosomes this lies parallel to the long axis of the spindle, but in the others more or less oblique to it, or at right angles to it (Fig. 4). In the spermatogonic divisions, on the contrary, as is shown in preparations similarly treated, the longitudinal split lies transversely to the long axis of the spindle (Fig. 5). Karyokinesis separates originally distinct chromosomes, and the first maturation division is therefore reducing. In many cases the chromosomes can be seen to be composed of a

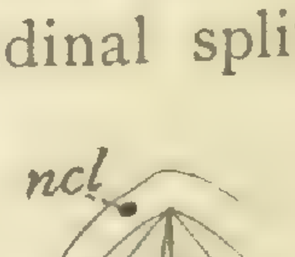

Fig. 4. — Equatorial plate of the first spermatocytic division. *ncl*, nucleolus

double row of four granules. After division the halves consist of a double row of two granules, or four in all, and thus simulate tetrads.

The true nature of the second maturation division, whether equational or reductional, is difficult to decide, because the length and the breadth of the chromosomes are approximately equal. Since most writers on the maturation of the germ cells in the arthropods agree in ascribing to them both methods of division (equation and reduction), it is probable that since the first division is reducing, the second is equational in Oniscus.

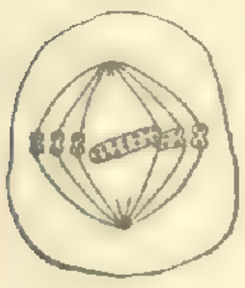

FIG. 5. — Equatorial plate of a spermatogonic division.

These results do not agree with those obtained by Rückert [1] and vom Rath [2] in the ovogenesis of the copepods. The case of Cyclops as described by Rückert is particularly clear. According to his observations the first maturation division is equational, the second reducing. If Rückert's interpretation of the method of reduction in Cyclops be correct, and my own concerning reduction in Oniscus be equally so, it becomes clear that the cell generation in which the true reduction takes place need not be the same for all members of a given class of animals.

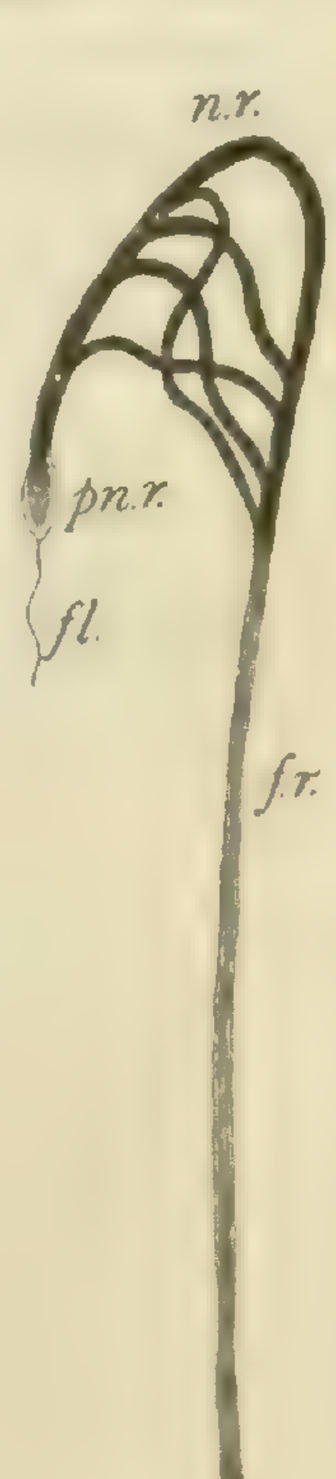

FIG. 6. — Anterior portion of mature sperm colony (less highly magnified). *fl.*, flagellum; *pn.r.*, prenuclear region; *n.r.*, nuclear region; *f.r.*, region of cytoplasmic fibres.

2. *Metamorphosis of the Spermatids.*

The transformation of the spermatids of the isopods has already been described by Gilson [3] in his comprehensive work on the

[1] Rückert, J. Die Chromatinreduktion der Chromosomenzahl im Entwicklungsgang der Organismen, *Merk. u. Bon. Erg.*, Bd. iii, 1893.

Id. Zur Eireifung bei Copepoden, *Merk. u. Bon. Erg.*, Anat. Heft, 1894.

[2] Vom Rath, O. Neue Beiträge zur Frage der Chromatinreduktion in der Samen- und Eireife, *A. M. A.*, 46, 1895.

[3] Gilson G. Spermatogénèse chez les Arthropodes, *La Cellule*, 1884 and 1886, tomes i and ii.

spermatogenesis of the arthropods. In some respects my observations agree with his; in others they differ.

The nuclei of the spermatids in Oniscus undergo a gradual elongation and condensation. During this process the cell walls between adjacent spermatids disappear and groups of nuclei are formed lying in a common plasma. Within the latter arise bundles of fibres of great length. Gilson in his Fig. 320 shows a direct continuity of these cytoplasmic fibrils with the elongated nuclei. That such a connection actually exists I have been unable to convince myself. In addition to the bundle of fibres there are single fibres of greater delicacy which are continuous with the nuclei. The appearance of the mature sperm colony may be seen from Fig. 6. Figs. 7 and 8 represent longitudinal and transverse sections of immature colonies. With Wilcox's double stain of saffranin and malachite green the cytoplasmic fibres stain green and are thus sharply differentiated from the nuclei, which stain red. In cross-section the nuclei are seen as a circle of red dots surrounding a group of green dots, the cytoplasmic fibrils. In examining a series of sections from the nuclear region towards the flagellum, the group of green dots in the center eventually ceases to be visible, and the surrounding red dots gradually merge into converging green fibres of great delicacy (Figs. 7 and 8). The evidence at my disposal admits of two interpretations, — either the long bundle of cytoplasmic fibres stops abruptly before the anterior end of the bundle is reached, and they thus have no connection with the nuclei, or the connection is of such a character as to escape observation. Since the structures concerned are extremely minute and delicate, the latter might easily be the case.

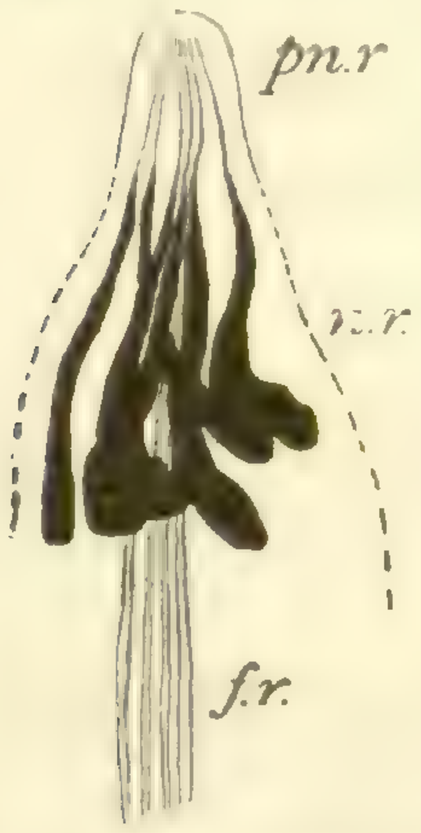

FIG. 7. — Longitudinal section of the anterior portion of an immature sperm colony. *pn.r.*, prenuclear region; *n.r.*, nuclear region; *f.r.*, region of cytoplasmic fibres.

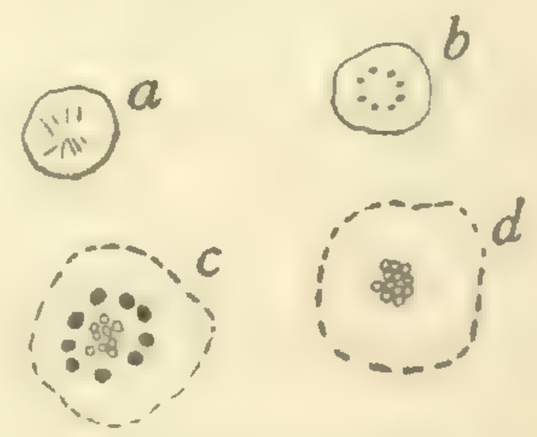

FIG. 8. — Cross-section of immature sperm colony. *a*, prenuclear region; *b* and *c*, nuclear region; *d*, region of cytoplasmic fibres.

III. Summary.

The main results of this study may be briefly summarized as follows:

1. The spermatogonic chromosomes are joined together in pairs in the synapsis to form sixteen bivalent chromosomes.

2. A longitudinal splitting of the thread takes place at this stage.

3. The distinctness maintained by the chromosomes up to the formation of the nuclear network of the resting spermatocyte and the manner of origin of the spermatocytic chromosomes from it lends support to the theory of their individuality in the resting nucleus.

4. In the structure and mode of origin of the bivalent chromosomes two main types may be distinguished: (*a*) the component chromosomes lie end to end, or (*b*) they lie side by side.

5. Inasmuch as univalent chromosomes are separated, the first maturation division is reducing.

6. Sphere substance (idiozome) is not observable, except for a short time during the prophases of the first spermatocyte.

7. The nucleolus of the spermatogonia disappears shortly after dissolution of the nuclear membrane, while that of the spermatocytes, first discovered in the synapsis, persists throughout the divisions.

8. The spermatids become associated in groups to form colonies of nuclei lying in a common plasma.

9. Within the latter arise bundles of fibres of great length, whose connection with the nuclei could not be demonstrated,[1] as well as single fibres of greater delicacy which are continuous with the nuclei.

10. The mature sperm colony consists of a variable number of filamentous nuclei contained, together with the bundle of cytoplasmic fibres, in a tenuous sheath which is flagellate at its anterior extremity.

[1] If such a connection is actual, it is slight and occurs very late.

I wish to express here sincere gratitude to my instructors, Dr. E. G. Conklin and Dr. Thomas H. Montgomery, Jr., for the valuable advice which has aided me in bringing this work to a successful completion.

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ON THE FORMATION OF SPECIFIC ANTI-BODIES IN THE BLOOD, FOLLOWING UPON TREATMENT WITH THE SERA OF DIFFERENT ANIMALS.

GEORGE H. F. NUTTALL.

During the thirteen years which have elapsed since I demonstrated the existence of bactericidal properties in the blood, pericardial and pleuritic fluids, a great deal has been discovered relating to other properties of the blood. The experiments referred to directly stimulated the researches which led to the discovery of the presence of anti-toxic, agglutinative, hæmolytic, and cellulicidal properties in blood serum. We have, moreover, learnt of the existence of a number of bodies which neutralize the action of these various substances.

More recently specific bodies or precipitins have been seen to occur in the serum of animals treated with the products of certain bacteria, with various kinds of milk, with peptone, egg albumin, and different kinds of blood.

Kraus ('97) was the first to demonstrate the existence of specific precipitins in the blood serum of animals immunified against cholera, typhoid, and plague. His results were subsequently confirmed by Nicolle and Marmorek. In these experiments the various anti-sera were added to clear culture-filtrates of the particular bacterium, and a precipitum was seen to occur in the filtrates of those cultures only to which the homologous anti-serum was added.

Bordet first demonstrated the existence of specific anti-bodies for milk. He treated animals with milk. After a time it was seen that their serum when added to a milk dilution brought about a precipitation. A precipitum was formed only when the anti-serum was added to the particular milk against which

the animal had been immunified. These results have been confirmed by Wassermann and Schütze, and demonstrate that there are essential differences in the composition of the albuminous molecule in the milks of man, cattle, and goat.

Myers demonstrated the existence of precipitins in the blood of animals treated with peptone, the precipitins acting only upon peptone.

The credit of having discovered the existence of specific precipitins in the bodies of animals treated with blood belongs to Tchistovitch. He inoculated animals with eel serum, which is toxic, and noticed that an anti-toxin made its appearance in the serum of the treated animals, but in addition their serum acquired the property of producing a precipitation when added to eel serum, whereas it did not act on other sera. A specific anti-body was also produced in rabbits treated with horse serum. Bordet demonstrated the existence of specific precipitins in rabbits which had been treated with fowl's blood. The anti-serum of these rabbits also produced a slight reaction in pigeon blood, showing that the bloods of the fowl and pigeon are of a somewhat similar composition. Nolf separated the corpuscles from the serum and treated two sets of animals with the separated blood ingredients. He found that only the serum-treated animals yielded the specific precipitin. He treated the serum with magnesium sulphate, thus removing the globulin. Animals were treated with globulin and albumin solutions derived from the serum, and it was found that precipitins were formed only in the serum of animals treated with globulin solutions.

Myers treated rabbits with fowl's egg albumin, as also with serum globulin of the sheep and bullock. He also observed the formation of specific precipitins in the serum of the treated animals, although a slight reaction took place on adding the anti-serum for sheep globulin to that for ox globulin and *vice versa*. Uhlenhuth also treated rabbits with egg albumin, and found that the anti-serum gave a reaction with 1 : 100,000 dilutions of egg albumin, whereas the most delicate chemical tests only gave a reaction with dilutions of 1 : 1000. He made the interesting observations that the precipitin appeared in the

serum of a rabbit which had been fed for twenty-four days with white of egg.

Leclainche and Vallée treated animals with albuminous urine and found that the serum of the treated animals contained a precipitin which acted upon the albuminous human urine with which they had been treated but not upon albuminous urine from the cow and horse.

Uhlenhuth treated rabbits with human blood and that of the ox, and observed the formation of specific precipitins in their serum which was tested on nineteen bloods derived from different animals. He obtained a reaction with a solution made from human blood which had been dried one month. Wassermann and Schütze made similar observations, testing twenty-three kinds of blood. Stern, who also experimented along these lines, found that the blood of three species of monkey gave a slight reaction with the serum of rabbits treated with human blood. In addition to other observations of a confirmatory character Mertens has found that the blood of a young rabbit born of a human serum-treated mother also contained the specific precipitin in its blood. The last observations which I shall mention are those of Dieudonné, and of Zuelzer, whose results are merely confirmatory in character. The majority of the publications referred to have appeared since I began my researches in January.[1]

I have injected rabbits intraperitoneally with the serum of man, the ox, sheep, horse, dog, and cat, and have been able to observe the formation of anti-bodies in the sera of all the rabbits excepting those treated with cat serum. The anti-sera have been tried on forty-five kinds of blood.[2]

The serum of rabbits treated with dog serum, added to all these bloods, gave a negative reaction throughout, excepting in the case of the dog. The tested dog blood was dried and dissolved in salt solution or used in the form of diluted fluid

[1] Full details of these experiments will appear in the forthcoming number of the *Journal of Hygiene*, vol. i (July 1), No. 3.

[2] Since the above was written, over one hundred and forty bloods have been tested — with uniform results. Fully realizing the interest of these tests from the point of view of zoölogical classification, the study is being pursued on an extensive scale.

serum. Whereas a marked and almost immediate precipitation occurred on the addition of the specific anti-serum to dog's blood, all the other blood solutions remained perfectly clear.

The serum of rabbits treated with sheep serum only produced a marked precipitum with sheep serum or blood solution. All the other sera and bloods remained perfectly clear, excepting those of the axis deer, gazelle and ox, in which a slight reaction took place, and those of the squirrel and swan, in which there was very slight clouding.

The serum of rabbits treated with ox serum only produced a marked precipitation in ox-serum dilutions, or dried ox-blood solutions. All the other bloods gave a negative reaction, a slight clouding only being produced in blood solutions of the sheep, gnu, axis deer, and gazelle, a slight opalescence appearing with that of the squirrel and swan.

The serum of rabbits treated with horse serum only produced precipitation in dilutions of horse's blood or serum, not even a clouding in any of the other bloods noted.

The serum of the rabbits treated with human blood, serum, and pleuritic exudation, only produced a marked precipitation in human blood solutions, etc. The blood of the four monkeys gave a slight but distinct reaction. A very faint clouding at times appeared in the solutions of the bloods of the horse, ox, and sheep, whereas all the other bloods remained perfectly clear. The test gave positive results when made with diluted human serum, pleuritic exudation, both fresh and putrid, blood and serum which had been dried on filter-paper and on glass plates, *with blood which had undergone putrefaction for two months*, with the blood of several persons who had cut themselves (blood collected on filter-paper), and with the serum from a blister following a burn on the hand and pressure on the foot. Both nasal and lachrymal secretion gave a slight but decided reaction. A faint clouding was produced in normal urine. That the precipitum formed in putrid blood dilution was specific was proved by adding the anti-sera of rabbits treated with ox, sheep, and dog serum to the blood dilution, no reaction resulting.

The tests made with dried blood, whether dried on glass or filter-paper, gave perfect reactions, as did also 1:100 dilutions kept for two weeks in test-tubes in the laboratory. Although chloroform had been dropped into the bottom of these tubes, molds occasionally developed upon the surface of the serum; but this seemed in no way to interfere with the specific reaction. Strips of filter-paper upon which both sheep and ox blood had been allowed to dry were placed under different conditions. Some were kept for two months at 37° C. in the dark; others at room temperature in the dark, and in diffused light for the same period; others again were exposed for eight days to the action of sunlight in a window. All of these samples gave apparently just as good reactions as fresh bloods, though of course our method cannot as yet be strictly considered to be quantitative. The body in the serum which is acted upon by the anti-serum, and the specific body in anti-serum, seem to be about equally resistant. Anti-serum dried for forty-two days on filter-paper and then dissolved in salt solution was found to give a perfectly characteristic reaction when added to its homologous (ox) serum, the latter diluted (1:100) as usual; it did not, however, produce a reaction in dilutions of other bloods. Dried normal sera exposed for half an hour to a temperature of 100° C. still gave a clear reaction, as did also 1:100 dilutions exposed for half an hour to 55°. As I first showed, the bactericidal properties of blood are destroyed at the latter temperature. Dilutions of blood exposed to a temperature of 100° gave no reaction.

The first rabbit in the series treated by horse-serum injections received old anti-toxic serum which had been kept at room temperature in the laboratory for *two years and seven months*. We are indebted to Dr. Louis Cobbett for this serum. The serum, to which trikresol had been added, had been kept in a corked bottle, exposed to diffused light, the temperature of the room being very high during the summer months. The first and second rabbits of the series treated with human pleuritic exudation, etc., received only one and two injections respectively of fresh serum, being treated for the rest of the time with pleuritic effusion which had been kept at room temperature for

five to six months. The pleuritic fluid had been preserved in a corked bottle with chloroform. These observations seem to me to possess a particular interest.

It seemed of interest, from a medico-legal standpoint, to determine whether or no a *mixture* of several kinds of blood would prevent the detection of one of the bloods in the mixture; the presence of another blood might inhibit the action of the anti-serum. To determine this question 1 : 100 dilutions of two to six kinds of blood were mixed together in equal proportions and tested with *positive results.*

Conclusions.

1. The investigations we have made confirm and extend the observations of others with regard to the formation of specific precipitins in the blood serum of animals treated with various sera.

2. These precipitins are specific, although they may produce a slight reaction with the sera of allied animals.

3. The substance in serum which brings about the formation of a precipitin, as also the precipitin itself, are remarkably stable.

4. The new test can be successfully applied to a blood which has been mixed with that of several animals.

5. We have in this test the most delicate means hitherto discovered of detecting and differentiating bloods, and consequently we may hope that it will be put to forensic use.

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Cambridge, England.

THE COLORS OF THE CRAYFISH.

W. J. KENT.

Some time has been devoted during the past year to a study of the influence of environment upon the colors of the crayfish. The work has been confined in a large part to the species *Cambarus immunis*.

It was first noticed, while studying the habits of crayfish by observations in field work, that the color of *immunis* in nearly all cases closely resembled the color of the environment. In one small pond of water, where the soil at the bottom was a blue clay, the crayfish were all blue in color. In another pond with a black, muddy bottom they were all black, and in still other places of different colors. But in nearly all cases they were of the same color as the environment.

One exception to this was found with those which were red. These were confined entirely to the shallow water in the small streams, and the color was not always similar to the color of the environment. The crayfish in all colors except red were found almost entirely in the ponds with deeper water and muddy bottoms. But it was discovered later that this red color in crayfish may be caused by exposure to sunlight. This was first observed while making a microscopic study of the pigment, to which most of the color of the crayfish is due. This pigment when removed from the crayfish and exposed to the sunlight turned red in a short time. The same result occurred when all effects of heat were excluded by using diffused light and an alum bath.

The influence of sunlight upon the color of living crayfish was studied further by experimenting in the laboratory. Crayfish of various colors were kept in an aquarium exposed to the light. This is a difficult experiment to carry out. Crayfish which live in deeper water become strongly photopathic and can endure only very weak light. It was necessary at first to

place the aquarium with the crayfish in diffused light and to allow them to become accustomed by degrees to changed conditions.

Some very good results were obtained in these experiments. Crayfish in black, blue, and green colors were changed to brown and red under the influence of light. These color changes, however, were very slow. Several months were required to produce distinct changes.

Other experiments were made in the laboratory upon the influence of environment on the color of the crayfish. A number were taken from different places where they were of various colors and kept for some time in an aquarium. This aquarium tank was made of zinc and was partly covered to exclude the light. In some cases very distinct color changes occurred. This was especially true of those which were red and black. Out of a large number of crayfish of different colors which were kept in this way for several months, nearly all were changed to the same gray color of the zinc aquarium.

An excellent illustration of color changes is furnished by another species, *Cambarus diogenes*. These may be found in any of the smaller streams. In the early spring they vary much in color, but later in the year nearly all are red. The explanation here lies in the habits of this species. They burrow during winter and come out in the spring with more or less of the color of the soil. These colors are gradually turned to red in the open sunlight. There has been no opportunity for observations upon other burrowing crayfish, but what is true of *diogenes* is no doubt true of other species which burrow in winter.

Some little time was also spent in studying color changes in the young crayfish. This study was made during the months of April and May of the present year, and was confined to one species, *immunis*. The young of *immunis* are at first red. This red color, however, is not apparent to the unaided eye. The pigment layer of a young crayfish consists of a number of large chromatophores which lie directly below the chitinous integument. These color bodies are somewhat scattered, and the little color they give is scarcely noticeable in comparison

with the colors of some of the internal organs, which can also be seen. The color of the young crayfish should be studied with the microscope. The integument of the young crayfish is perfectly transparent, and with a microscope any changes in color in the chromatophores is easily observed.

A series of observations was made upon the young crayfish in one pond where the old were black and in another pond where the old were blue. In this pond where the old crayfish were black the young were at first red and gradually changed to black. This change of color required about two months' time. In crayfish one or two weeks old only a very few of the chromatophores showed any change in color, while in crayfish one month old possibly one-half of them would be changed in color, and in those from two to three months old the process of color change was nearly always complete. The integument remains transparent up to this age, so that all stages in color changes were readily seen.

In the second pond where the old crayfish were blue the young, which were red at first, changed to blue, this change requiring about the same length of time. In other places where the old crayfish were red the young crayfish underwent no change in color. They were red at first and remained red in color. In this work the young crayfish of different ages were brought into the laboratory and examined. The color changes were such as occur among crayfish in their natural environment and under ordinary conditions. No attempt was made to keep them in the laboratory for the purpose of experiments.

From these observations it will be seen that the colors of crayfish are due to two causes. The sunlight produces the red color, though this same color may be caused by the environment. All colors excepting red are due to the influence of environment. In all cases these colors serve as a protection against enemies.

The greater part of this work has been confined to one species, *Cambarus immunis*, although some work has been done on three other species, *propinquus*, *bartonii*, and *diogenes*. But there seems to be no reason why similar changes in color should not occur among all other species.

A word should be said here against too hasty conclusions on this subject of colors. Many species of crayfish are migratory in their habits. This is especially true of those living in running water. The changes in color require some weeks or possibly months of time. For these reasons the color of crayfish seen in the small streams may not be at all like the color of the environment. The best results will be obtained from a study of the crayfish in the small ponds of water where migrations cannot occur.

NOTES AND LITERATURE.

GENERAL BIOLOGY.

Arnold's Sea Beach at Ebb Tide.[1] — This is the type of book which one wishes had been written years ago. Every one will recall his struggles when he first began seashore collecting; the vain attempts to identify the specimens found and in some cases even to ascertain the relationship of certain forms. Such a volume as this would have lightened the labors and have given additional pleasure to a trip to the shore. Although late in coming, it is none the less welcome and will doubtless be of great value to many beginners. The tendency of the past dozen years has been to stand in morphological and physiological lines, and the systematic side of **biology has been too much neglected.**

This volume simplifies many of the collector's difficulties, for with simple descriptions and characteristic figures it enables one to recognize a large number of the animals and plants found on the American coasts from Mt. Desert to Florida; from Puget Sound to San Diego. It begins with hints on collecting and preserving specimens and then takes up, in systematic order, the algæ, sponges, cœlenterates, worms, molluscoids, echinoderms, arthropods, mollusks, and tunicates, describing and usually figuring the more common species. Each of these groups has a section or chapter devoted to it, and the descriptions are prefaced by an outline of the morphology, life-history, and economic relations of the group.

In looking more closely at the text one notices certain blemishes which are almost unavoidable in a work of such large scope and which will doubtless disappear in future editions, for future editions there will certainly be. Thus in the chapter on collecting there should be directions for killing the animals properly, and there certainly should be some hints as to the use of formal as a preserving fluid. Again, there is noticeable a lack of symmetry in terminology. Thus among the decapods we find that Gelasimus has given way to

[1] Arnold, Augusta Foote. *The Sea Beach at Ebb Tide*, a guide to the study of the seaweeds and the lower forms of animal life found between tide marks, with more than 600 illustrations. New York. The Century Company. 1901. x + 490 pp.

Uca, while Homarus remains ; in the mollusk the latest vagaries of the systematist are introduced, while in the worms a more conservative course has been adopted. Here and there errors occur. Thus the nemertines are regarded as a class of Plathelminthes, and (p. 164) the flatworms are stated to lack an anus. Under the Gephyræa, *Sipunculus nudus* is included as an American form, while Echiurus and Thalassema are ignored. Yet these are minor blemishes, and the work will prove most useful not only to the casual visitor to the shore but to the more experienced naturalist as well. K.

PHYSIOLOGY.

Reactions of Hydra to an Electric Current. — Pearl [1] has observed that *Hydra viridis*, when attached by the foot and placed in the path of a constant current of weak intensity, brings the long axis of the body in line with the current, the oral end being toward the anode. This orientation is accomplished by a contraction on the anode side of the body. When the animal is not attached by the foot, the anode side still remains the side of contraction, even though the oral end may be turned toward the cathode. In addition to orientation, the current may call forth general contractions. Separate pieces of the hydra react in much the same way as whole animals. Buds and parent animals are independent in their reactions, the buds showing essentially the same reactions as adults. P.

Evolution of Pigment. — The interest which biologists have shown in the chemical activities of protoplasm has evinced itself in the study of pigment as a protoplasmic product. Bohn's [2] contribution to this subject is a timely *résumé* of some of the more important recent results. The pigments are classified as hydrocarbons, derivatives of chromatin, and derivatives of the aromatic series. The vegetable pigments are described under the heads of chromogenic bacteria and chloroleucites. The occurrence, migration, and transformation of animal pigments occupies much of the volume. The author believes that in a given cell there may be a struggle between

[1] Pearl, R. The Reactions of Hydra to the Constant Current, *Amer. Journ. Physiol.*, vol. v (1901), pp. 301–320.

[2] Bohn, G. *L'Évolution du Pigment.* Paris, Carré et Naud, 1901. 96 pp.

the various classes of pigment granules, resulting in a selection of the more favored kind. In consequence of this a harmony of color would prevail, first locally and finally throughout the organism. P.

Excretion in Annelids. — The elimination of waste products from the bodies of annelids, particularly earthworms, has been fully studied by Willem and Minne.[1] In Lumbricus reserve products in the form of fat and of glycogen occur, the former in the ciliated cells of the intestinal epithelium, the latter in the peritoneal cells. True waste products are found in the same animal as guanine in the chloragogic cells and nephridial tubules, as uric acid in the peritoneal cells and similar elements found between the fibres of the body musculature, and as cholesterine probably in all tissues. The chloragogic cells produce guanine with more or less regularity. This is periodically discharged from these cells into the cœlomic fluid, where in common with other particles it is engulfed by the free cœlomic cells. The cœlomic cells when charged with the products of excretion make their way through the intestinal epithelium and are finally discharged into the digestive cavity The nephridial walls excrete soluble materials exclusively. Only a small amount of cœlomic fluid passes through the nephridial canal. This fluid is kept in motion by the cilia of the canal and the waste products are thus discharged.

Similar studies were made on Nereis, Nephelis, and Clepsine, and the following general conclusion drawn. In all the annelids studied the cells that line those parts of the cœlom particularly connected with the circulatory system are of service in purifying the blood. They accumulate in their protoplasm various excretory products, in some annelids one, in others another. Thus far the following substances have been identified : uric acid, guanine, sodic urate, and a substance like chitine. Many annelids show a tendency toward the obliteration of the nephrostomes, and this is accompanied by a change in the way in which the solid excreta are discharged. Cast out freely in those worms with large nephridial funnels, these products in worms with restricted nephridia are accumulated and disintegrated in the phagocytic organs and thus prepared for discharge. P.

[1] Willem, V., et Minne, A. Recherches sur l'Excrétion chez quelques Annélides, *Mém. l'Acad. roy. de Belgique*, tome lviii (1900), pp. 1–73, Pls. I–IV.

ZOÖLOGY.

Coccidæ Americanæ. — The work bearing this title consists of a series of specimens neatly arranged in a portfolio, with sufficient printed matter to explain where descriptions of them will be found, and what plants they infest. The part just issued by Messrs. Quaintance and Scott of Georgia is the second of the series, the first having been prepared in Florida by Messrs. Rolfs and Quaintance. Each part contains twenty species, most of them of economic importance, and all correctly named; so it will readily appear that the work is a very useful one for experiment-station workers and others who have to determine Coccidæ.

The only adverse criticism one can pass upon the part under review is that the synonymy given for the species is in many cases wrong; in several instances the alleged synonyms are not even congeneric. This results from the uncritical acceptance of the work of other authors, and the present writer has erred too often in a similar way to be very severe on the subject.

T. D. A. C.

Coccidæ Stanfordianæ. — It is a pleasure to receive from Stanford University four excellent papers on Coccidæ, written by the students of that institution. These papers are bound together as a contribution from the Hopkins Seaside Laboratory, and are as follows: (1) "Notes on Cerococcus," by Rose W. Patterson; (2) "New and Little-Known California Coccidæ," by S. I. Kuwana; (3) "The Redwood Mealy-Bug," by George A. Coleman; (4) "The San José Scale in Japan," by S. I. Kuwana. These papers are full of valuable information, and are accompanied by admirable plates. Miss Patterson describes and figures the three species of Cerococcus which occur on the Pacific slope (*C. quercus* Comst., *C. ehrhorni* Ckll., and *C. corticis* Twns. and Ckll.), giving many new facts. She is evidently unaware that a fourth species (*C. ficoides* Green) occurs in India. Mr. Kuwana gives for the first time an account of the transformations of *Pseudolecanium tokionis*, including the description of the adult male, which will be greatly appreciated by coccidologists. He also describes three new species in the genera Eriococcus, Ripersia, and Lecanium. The *Ripersia festucæ* is a peculiar creature, having the female elongated, much like the male larva of ordinary Ripersia. It might be referred to Pergandiella were the antennæ 8-jointed; possibly the discovery of the male will indicate its closer affinity with Fonscolombia.

'Mr. Coleman describes the redwood mealy-bug as *Dactylopius sequoiæ*, but, as Mr. Ehrhorn remarked to me, it is rather a Phenacoccus, notwithstanding the 8-jointed antennæ. It has certainly no affinity with the two species of Dactylopius it is said to most resemble. The description is very full, and includes all stages. T. D. A. C.

Fishes of Japan. — In the *Proceedings of the United States National Museum* (Vol. XXIII, pp. 739–769) Jordan and Snyder record the species of fishes collected in Japan by Mr. Pierre L. Jouy. These are eighty-three in number, six of them being new to science. These are *Leuciscus jouyi*, *Apogon unicolor*, *Pomacentrus rathbuni*, *Aboma tsushimæ*, *Chasmias misakius*, and *Watasea sivicola*. Chasmias is a new genus of gobies near Gillichthys, and Watasea a new brotulid near Neobythites. The new species are figured. I may here note that the name Chasmias is preoccupied by Chasmias Ashmead, a genus of Ichneumons, published a little earlier in the same proceedings. For the genus of fishes, Chasmichthys Jordan and Snyder may be substituted.

In the same paper is given an identification of the species of Japanese fishes collected by Dr. Thunberg and loosely described by Houttuyn in 1782. The adoption of Houttuyn's names necessitates several changes in nomenclature, among others the use of the name *Scomber japonicus* in place of *Scomber colias*, for the common chub mackerel.

Jordan and Snyder have begun a series of monographic reviews of families of Japanese fishes. The first now published (*Proceedings of the United States National Museum*, Vol. XXIII, pp. 725 734) includes the lancelets and lampreys, the second, the eels. In the first of these papers the new species are *Branchiostoma nakagawæ*, *Myxine garmani*, and *Lampetra mitsukurii*, the latter being a manuscript name of Dr. Hatta.

In the review of the eels, fifty species are described, of which nineteen are new, all of these and some of the others being figured. The new genera are Xyrias, near Cirrhimuræna, but without cirri, and Æmasia near Gymnothorax, but with the mouth bristling with large canines. D. S. J.

Fowler on Fishes in the Philadelphia Academy. — In the *Proceedings of the Academy of Natural Sciences* at Philadelphia (Vol. LIII) Mr. Henry W. Fowler gives a number of interesting notes on fishes. The types of new species of selachians in the academy museum are

redescribed with special reference to their anatomy. Among these are numerous types of species named in Bonaparte's *Fauna Italica*, purchased for the academy by Mr. T. B. Wilson.

The fishes recently noted by Mr. Fowler as from the Caroline Islands came from a coral reef called Caroline, or Thornton, Island, remote from the Carolines, and near Samoa.

From Mazatlan, Mexico, Mr. Fowler describes a new genus of Hemiramphidæ with the form of Fodiator and the long beak of Hemiramphus. The species is called *Hemiexocœtus caudimaculatus*. It is midway between the halfbeaks and the flying fishes.

The generic name Odontostomus, applied by Cocco to a deep-sea fish, is preoccupied in mollusks. In place of Odontostomus, Mr. Fowler proposes the new name Evermannella. The family, now composed of the two genera, Evermannella and Omosudis, becomes Evermannellidæ.

D. S. J.

Jordan and Snyder on New Fishes in the Museums of Japan. — In the *Journal of the College of Science of the Imperial University of Tokyo* (Vol. XV, Part II), Messrs. Jordan and Snyder have descriptions of nine new species of fishes in Japanese Museums of which no specimens are yet available except the original types.

These species are :

Acipenser kikuchii, from Sagami Bay.
Lepidopus aomori, from Aomori.
Tetrapturus mitsukurii, from Misaki and numerous other localities.
Tetrapturus mazara, from Misaki.
Bentenia æsticola, from Kashima.
Ebisus sagamius, from Misaki.
Reinhardtius matsuuræ, from Misaki.
Trachypterus ishikawæ, from off Tokyo.
Trachypterus ijimæ, from off Tokyo.

Of the two new genera, Bentenia is nearest Velifer and Pteraclis, and is distinguished by the anterior insertion of its dorsal and anal, each of which has one spine greatly enlarged.

Ebisus is a huge bass or jewfish, allied to Stereolepis but with the head unarmed and the teeth larger. It is locally known as Aburabozu, the "fat priest."

Dr. Mitsukuri has illustrated the paper by photographs of the type specimens, in so far as these are available.

D. S. J.

Check List of the Fishes of Japan. — In the series called *Annotationes Zoologicæ Japonenses* (Vol. III), published by the Zoölogical Society of Tokyo under the auspices of the Imperial University of Tokyo, Jordan and Snyder give a "Preliminary Check List of the Fishes of Japan." This catalogue is a neatly printed memoir of 159 pages.

It includes 686 species, exclusive of species from the Kuriles and Riu Kiu, mentioned in footnotes. The known localities in Japan are enumerated for each species, and the Japanese vernacular name of each is given. These vernacular names, corrected and largely compiled by Dr. C. Ishikawa, give the paper a special value to Japanese students.

The paper was in press before the authors planned their expedition to Japan in 1900. In this expedition upwards of 250 species were added to the list and a number of changes and corrections will be rendered necessary. The total number of species of fishes now known from the entire empire is between 1000 and 1100.

We may note that the new genus *Corusculus* (*beryxoides*) is identical with the earlier Eteliscus, having the same type. The appearance in the text of this needless name was the result of accident.

The paper is "dedicated to Professor Kakichi Mitsukuri of the University of Tokyo in recognition of his work as a naturalist and of his character as a man." It is to be hoped that this paper, written in America and published in Japan, may help serve the purpose of bringing Japanese science and that of the nations called Occidental into closer touch with each other. D. S. J.

Notes. — The spouting of the finback whale has been successfully observed by Henking (*Zool. Anzeiger*, Bd. XXIV, pp. 103-111, 1901) while off the Norwegian coast. The spout is not in any sense a jet of water, but is a cloud of water particles, as maintained first by Scoresby, and is driven out of the animal's nostrils by an operation not unlike a sneeze. The cloud usually has the outline of a reversed comma and Professor Henking's paper is noteworthy as containing the first accurate drawings of this outline.

The difficulty of ascertaining the exact limits of the ectoderm and the entoderm in the mouth cavity of vertebrates has been the chief obstacle in determining from which germ layer the hypophysis is derived. Zeleny (*Biological Bulletin*, Vol. II, pp. 267-281) has found that in turtles this organ is formed before the mouth breaks through and that it is derived from the ectoderm.

In a synopsis of the rice rats (Oryzomys) of the United States and Mexico, Merriam (*Proceedings of the Washington Academy of Sciences*, Vol. III, pp. 273–295) adds twenty-two new species and subspecies to the thirteen already known.

Phoronis pacifica, a new species described by H. B. Torrey (*Biological Bulletin*, Vol. II, pp. 283–288), is interesting as the first of this almost cosmopolitan genus to be taken on our west coast.

BOTANY.

Plant Life of Alabama.[1] — For nearly forty years the late Dr. Mohr gave close attention to the flora of his adopted home, Alabama; and the later years of his life were devoted to the preparation of a book embodying the results of his long study. He lived to see the last proof sheets corrected, but the date of its publication is a fortnight later than that of his death. A historical account of the botanical work done in Alabama, a detailed study of its physiography, geology, and meteorology, and a discussion of the general principles of plant distribution, lead to an analysis of the features marking the Alabama flora, which, more than any other North American work, exemplifies the trend of modern ecological study in a varied region; and the book closes with an annotated systematic catalogue of the spontaneous plants, including descriptions of new or critical species, a discussion of the relations of the flora to agriculture, and a list of plants known to be cultivated in the state. Considering Dr. Mohr's advanced age, it is remarkable that he should have adapted himself to the current trend of American botanists in regard to nomenclature, but in this, as in his grasp of the newer field problems in botany, he shows a plasticity far out of the ordinary run, and his work, which is of lasting value, is likely to produce nowhere the impression that a younger man, if possessed of his knowledge, could have done it better.

W. T.

Notes. — The varied and far-reaching character of the botanical work being done under the geological and natural history survey of Minnesota is shown by part 5 of the current series of *Minnesota*

[1] Mohr, Charles. Plant Life of Alabama, *Contr. U. S. Nat. Herb.*, vol. vi. 921 pp., with several plates. Washington, Government Printing Office, 1901.

Botanical Studies, bearing date July 20, which contains: A preliminary list of Minnesota Uredineæ, by E. M. Freeman, A new species of Alaria, by De Alton Saunders, A preliminary list of Minnesota Xylariaceæ, by F. K. Butters, A contribution to the knowledge of the flora of the Red River valley in Minnesota, by W. A. Wheeler, Observations on *Gigartina exasperata*, by H. B. Humphrey, Observations on the algæ of the St. Paul city water, by M. G. Fanning, Notes on some plants of Isle Royale, by W. A. Wheeler, Revegetation of Trestle Island, by D. Lange, Violet rusts of North America, by J. C. Arthur and E. W. D. Holway, and Observations on the embryogeny of Nelumbo, by H. L. Lyon. The number is unusually well illustrated.

Of interest to botanists, as well as ornithologists, is a pleasantly written account, by Dr. O. Widmann, of a visit to Audubon's birthplace, separately printed from *The Auk* of April.

Mr. Massee continues his redescriptions of Berkeley's types of fungi in No. 243 of the *Journal of the Linnean Society*.

Science of July 26 reprints from the London *Times* an article on the recent report of a committee appointed for the investigation of the botanical work carried on at Kew and South Kensington.

A biographic sketch of the late Prof. T. C. Porter, with portrait, appears in the July number of the *Bulletin of the Torrey Botanical Club*.

The flora of the Palouse region of Washington is the subject of a paper by Piper and Beattie, published in May by the Agricultural College of that state. It contains descriptions of all of the Spermatophytes and Pteridophytes known to grow wild within 35 kilometers of the town of Pullman, and is provided with keys to the families, genera, and species. In nomenclature, the Kew and Berlin rules have been followed.

A recent number of the *Gardeners' Chronicle* contains a figure, copied in the *Revue Horticole* of July 16, showing an Abyssinian landscape characterized by arboreous species of lobelia, which is as striking as the yucca, cactus, and other bizarre landscapes of arid regions on the American continent.

Mr. J. Medley Wood's *Natal Plants*, figuring and describing some of the more interesting constituents of a most interesting flora, has reached part 2 of the third volume.

The first part of Vol. V of the *Flora Capensis*, edited by Sir W. T. Thiselton-Dyer, extending from the Acanthaceæ to Clerodendron in the Verbenaceæ, has recently appeared from the press of Lovell Reeve & Co., of London, — unfortunately without indication of the date of issue.

An interesting essay on palms and their value to residents of tropical countries, by Professor Schröter of Zürich, constitutes the last *Neujahrsblatt of the Naturforschende Gesellschaft* of that city.

In connection with a monograph of garden beans recently published from the Missouri Botanical Garden, a paper by Professor Halsted on bean diseases and their remedies, constituting *Bulletin 151* of the New Jersey Agricultural Experiment Station, becomes of double interest. Like all of Professor Halsted's papers, it is well done.

PETROGRAPHY.

Origin of Corundum. — The interesting problem relative to the origin of corundum in basic rocks has been attacked by Pratt[1] through the study of slags. He finds that the separation of corundum from magmas is dependent upon the composition of the magma, upon the character of the oxides dissolved in it, and upon the quantity of alumina present.

When the magma is a calcium-sodium silicate, corundum separates only when the ratio of Al_2O_3 to the other bases exceeds 1 : 1, and the ratio of SiO_2 is less than 6. If Mg and Fe are present, no corundum will form unless there is more than enough Al_2O_3 present to unite with these bases.

When the magma is a magnesium silicate without excess of Mg, all the Al_2O_3 will separate. If Mg is in excess, some of the Al_2O_3 will unite with this, forming spinel, and the remainder will separate. When Cr_2O_3 is present and only a little Al_2O_3 and MgO, these unite with the Cr_2O_3, yielding chromite. No corundum is formed.

When alkalies or alkaline earths are present, the Al_2O_3 tends to unite with these in the formation of feldspars. There is, however, little tendency to the formation of Mg-Al silicates when the magma is a magnesium silicate.

[1] *Amer. Journ. Sci.* (1899), p. 277.

The Calculation of Rock Analyses. — Now that so much interest centers about the chemical composition of rock magmas and the representation of their composition in terms of molecular ratios, a recent paper by Kemp[1] on the methods of calculating rock analyses in these terms will be of great use to all students of rocks. In this paper the author shows how to transform percentages into molecular proportions, and from these how to calculate the mineral composition of any given rock. The most valuable portion of the article is a series of tables in which the "molecular proportions" of each of the rock-forming oxides is indicated for its corresponding "percentage" in rock analyses.

Weathering of Granites. — The conclusions drawn by Watson[2] from the results of an interesting study of the weathering of a number of granitic rocks of Georgia are as follows: Assuming that Fe_2O_3 has remained constant, (1) the amount of water in the weathered rocks increases rapidly as decomposition advances. At the same time there is a loss of SiO_2 and of all the metallic oxides except Al_2O_2, which in some cases shows a relative increase. (2) The loss of SiO_2 is not caused by solution of the quartz of the original rocks, but is the result of the decomposition of silicates. (3) CaO and Na_2O disappeared in larger quantities than MgO and K_2O. (4) The total loss of constituents varies between 7.68 % in weathered phases to 71.82 % in thoroughly decomposed forms.

Origin of Phenocrysts in Granites. — The same author[3] has also investigated these granites with respect to the origin of their phenocrysts. He describes in detail a large number of occurrences and concludes his study in these words: "The absence of (*a*) definite arrangement or orientation among the phenocrysts; (*b*) of phenocrysts from the border zones of the massif — gradation from an interior porphyritic facies peripherally into an even granular granite of coarse texture and the same mineral and chemical composition; (*c*) the further absence of evidence of magmatic resorption or corrosion of the phenocrysts; and (*d*) the presence of abundant inclusions of all the ground-mass constituents characterizing the generally tabular phenocrysts of the Georgia porphyritic granites, fully justify the conclusion that the phenocrysts in these rocks were formed *in place*, and are not intratelluric in origin."

[1] *School of Mines Quart.*, vol. xxii, p. 75.
[2] *Bull. Geol. Soc. Amer.*, vol. xii (1901), p. 93.
[3] *Journal of Geology*, vol. ix (1901), p. 97.

The granites are found in the Piedmont plateau region. They comprise even-grained and porphyritic varieties, and granite gneisses, all of which are plainly intrusive. Each variety is clearly described by the author, who also gives analyses of many types. Averages of these analyses give the following figures:

	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O
Normal granites	69.67	16.63	1.28	.55	2.16	4.73	4.71
Porphyritic granites	69.28	16.73	1.75	.72	2.13	4.33	4.59
Granite-gneisses	73.76	14.52	1.03	.29	1.14	4.16	4.63

The normal and porphyritic phases possess the same composition. The gneisses, however, are more acid than these, while their percentages of Al_2O_3, CaO, and MgO decrease.[1]

Gneisses of the Adirondacks. — The gneisses of a portion of the Adirondacks are briefly described by Cushing[2] in a report on the geology of Franklin County, New York. They comprise granite-gneisses with the composition of hornblende-granites, and pyroxene-gneisses. The latter consist of pyroxene (augite and hypersthene), plagioclase, orthoclase, some hornblende and quartz. Intermediate gneisses composed of hornblende and andesine, with augite and hypersthene as common accessory constituents, are also present in some localities. These are identical in their features with certain hornblende-gneisses derived from gabbros, but the author is inclined to separate them from the latter as of different age. Intrusive in these gneisses and in the Grenville series of sediments which are so well represented in the district are great dykes and masses of anorthosite, gabbro, granite, diabase, and syenite porphyries. The various types of most of these rocks have been described many times. The author adds new descriptions which serve to show that the types are quite uniform over large areas. The syenite grades into granite, both rocks being regarded as differentiates of one magma. The syenites are composed essentially of orthoclase and albite or oligoclase in microperthitic intergrowths, augite, hypersthene or bronzite and quartz. Hornblende is nearly always present to some extent. With the increase in this component the hypersthene diminishes. The rock varies rapidly in composition and structure. All the intrusions except the diabases and porphyries have been subjected to great pressure and have yielded gneisses.

[1] *Amer. Geologist*, xxvii (1901), p. 199.
[2] *18th Report State Geologist*, Albany, N. Y., 1900.

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THE AMERICAN NATURALIST

A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

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THE

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REGENERATION IN THE EGG, EMBRYO, AND ADULT.

T. H. MORGAN.

THE term "regeneration" has come to mean not only the replacement of a lost part, but also the production of a whole organism from a piece of an animal or of a plant. There are even other phenomena that must be included under the same term, such as, the production of a part different in kind from the one lost, and also, as I shall try to show, those cases in which a part of an egg or of an embryo produces a whole or a part of an organism. It appears that there are two principal modes by which regeneration takes place. The first and more familiar process is by means of the formation of new tissue at the exposed region, followed by the development of new organs out of this new tissue. In order to distinguish this mode from the other, we may call it "epimorphosis." The second mode of regeneration is brought about by the transformation of the entire piece into a new form. For this process I have proposed the term "morphallaxis." These two modes of regeneration are not sharply separated, for we find in some forms — noticeably in the planarians — both processes combining to produce a new organism.

It has been only within the last few years that zoölogists have discovered that parts of the embryo, or even of the unsegmented egg, have also the power of producing new, whole organisms, and while this process has been here and there brought into relation with the process of regeneration, — especially by Roux and by Barfurth, — yet up to the present time no systematic analysis has been carried out in order to see how far the regeneration of pieces of an adult organism and of pieces of the egg are similar or identical processes. It is the special object of this paper to examine further into this question.

I.

In order to make clear our subsequent comparison between the development of pieces of the adult and of the egg and embryo it will be necessary in the first place to review briefly a few well-known facts. It has been stated that there are, in general, two modes by which a piece of an adult may regenerate: (*A*) either by the development of new tissue at the exposed regions, — epimorphosis; or (*B*) by transformation of the old part into a new form, — morphallaxis.

(*A*) *a*. Furthermore, we find under the first category that when a small piece of the organism is removed (1) the organism regenerates as much as is lost; but (2), on the other hand, the small piece does not generally make the whole organism, if in fact it regenerates at all. As examples of these different processes I may cite the following cases If the leg is cut from a newt, the larger piece — the newt — makes a new leg, but the leg does not make a new newt. If the head is cut from a snail, the snail makes a new head, — if the cut has not been made too far back, — but the head does not make a new snail. If it be objected that in both cases the smaller piece dies before regeneration can begin, I may cite another experiment made on the earthworm. If a few anterior segments are cut off, they do not make a new worm, although the piece may remain alive for a long time without showing any signs of regeneration, and during this time the larger piece, from which the anterior end had been cut off, may have

completely replaced the lost smaller part. It may also be stated that the result is not dependent upon a lack of material in the small piece, for the process of regeneration does not even begin, and, as other experiments have shown, there is certainly enough material in the small piece for regeneration to have been carried out to some considerable extent.

b. The other case in this category is that in which the large piece produces only the distal end of the part removed and, therefore, less than the part cut off. For instance, if more than five segments are taken from the anterior end of the earthworm, still only five are regenerated, and the intermediate region is never regained. In the planarian, if more than the head is cut off, only the head is *at first* regenerated, but in this case the intermediate, or missing region, is made good by subsequent changes that take place in the region behind the new head and in front of the old part. A similar thing happens when the posterior end is cut from an earthworm. At first only a small part comes back, consisting of the end-piece — the telson — and a few segments, but by subsequent growth new segments are intercalated near the posterior end just in front of the telson. Again, if the tail of a fish is cut off near its base, there appears at first only *a small new part that assumes the characteristic form of the tail, even before the new part has grown out to the level at which the tail was cut off.* Subsequently, by a process of continuous growth, the entire tail is replaced.

(*B*) *a*. The second mode in which the process of regeneration takes place is, as I have said, by the transformation of the entire piece into a new organism. This is known to occur only in those forms that we speak of as the lower animals, but in which, nevertheless, a high degree of specialization may exist. The most familiar case, and the one longest known, is that of hydra. Trembley saw that small pieces may change into new, whole animals, and subsequent investigators have observed the same thing. They have not, however, pointed out specifically that new tissue is not added at the cut-ends, but from personal observation I can state that there is no special development of new tissue in these regions. The entire piece changes over

into the new form. Another example of the same process, first made known by Bickford, is that of Tubularia. In this form it is even more evident that a piece of the stem may be transformed into a new hydranth without new tissue forming beyond the level of the cut-end.

In planarians we find not only new tissue developing at the cut-end, but also a transformation taking place in the old parts. The Protozoa also regenerate by changing over the old part into a new form. From the figures given by Gruber and others there can be little question that the piece is transformed directly into a new whole, although this important fact has not been emphasized by those who have written on the subject. A piece of Stentor, for example, if it contains one or more nodes of the macronucleus, produces a new Stentor having the characteristic form, but on a smaller scale. I have repeated this experiment on Stentor, and have found that small pieces produce new organs that are of proportionate size.

In these cases of morphallaxis, just described, the small pieces change over into the characteristic form of the species, *i.e.*, they are new wholes of smaller size. They may subsequently grow to the full normal size, and even produce sexual organs. On the other hand, there is known at least one case in which very small pieces produce not a whole form, but only a part of a whole. It has been shown that very short pieces of the stem of Tubularia may produce only the distal end of the hydranth, *viz.*, a proboscis. Other experiments show that, nevertheless, the material out of which the proboscis develops is totipotent. This problem will be more fully discussed later in another connection. The result also suggests direct comparison with those cases in which only a part of what has been removed is regenerated out of the new tissue that appears at the cut-end, as when only a few anterior segments regenerate in the earthworm after the removal of a much greater number. In fact, I think it may be shown that there is something more than a mere similarity between the two cases, and that they both result from the action of the same factors.

We may next examine some of the cases in which a part of the egg, or of the embryo, produces an entire organism. The

earliest observation of this sort was made by Haeckel in 1870. Pieces of the embryo of a jellyfish were found to produce each a new smaller embryo which gave rise to an entire organism. This discovery attracted little or no attention at the time, because the important theoretical questions that are involved were not appreciated. Without treating the facts in the order of their historical sequence I shall describe a few other results that have a direct bearing on the questions before us.

The development of isolated blastomeres is one of the simplest cases of the kind. If the first two blastomeres or cells of the egg of the sea-urchin be separated from each other, each continues to segment, in most cases as though it were still a part of a whole. There is produced a half blastula open at the side that corresponds to the region at which the other blastomere lay at the two-cell stage. The half sphere next closes in to become a whole sphere of half size, and from this time onwards the embryo continues to develop as a symmetrical whole, passing through the later stages as does the normal, whole embryo.

These results show that after separation of the blastomeres each continues to develop for a time in the same way that it would have done had it remained in contact with its fellow; but the process of half development is only carried through the cleavage stages, and then a new change takes place, initiated by the closing of the open side, and a new whole of half size is established. It is this process of closing of the opening and the subsequent whole development of the half piece that resemble the changes that take place in the regeneration of pieces of adult animals.

In other species of sea-urchins the isolated blastomeres behave in a somewhat different way. In Sphærechinus the cleavage is not so obviously a half cleavage, or at least while the first divisions may be more or less like those of a blastomere that remains in contact with its fellow, yet there is not formed an open half sphere, but the blastomeres close in as they are formed. A whole embryo of half size is also produced in this case.

In another sea-urchin, Toxopneustes, it has been found that after separation of the blastomeres the cleavage may proceed

at once as a whole, *i.e.*, the isolated blastomere divides in the same way that the whole egg divides, and not as it would have divided had it remained in contact with its fellow. The blastula is closed from the beginning. Later, as in the other cases, a whole embryo develops.

These and other experiments seem to show that the form of cleavage of the egg is the result of an arrangement or structure of the protoplasm, and that in some cases this same arrangement is retained after the separation of the blastomeres; while in other cases the protoplasm may rearrange itself at once into a new whole, in which the arrangement of the parts is symmetrical and like that of the whole egg. The blastomere divides in consequence in the same way as does the egg.

The closing in of the half blastula of Echinus presents certain obvious resemblances to the closing in of pieces of adult animals. Several writers have supposed that in both cases this change is due to a simple physical rearrangement of the material, but it is, I think, not altogether improbable that at least one other factor is also present. I base my opinion on the study that I have made of the closing in of pieces of Tubularia, of hydra, and of the closing of large wounds made in the side of very young tadpoles. While the closing in seems to be the result, in part, of the physical property of the semifluid substance to become round, or more symmetrical, it seems also to involve certain contractile phenomena of a different sort. The cells that are in contact draw towards each other as a result of their own movement or contractility. There may be also certain tactic phenomena present. At least, if we cannot show positively that some such factors may be at work we have at least no right to exclude them in the present state of our knowledge as possible factors in the result.

After the closing of the half blastula has taken place we find that the piece no longer behaves as a part, but as a new whole. We must assume that it has become a symmetrical or whole structure. Let us look somewhat further into this question.

We have seen that in the case of the egg the change that takes place in a piece, making the piece symmetrical, may be brought about by a simple physical rearrangement of the

substances of the protoplasm; but after the piece has been divided into parts or cells the contents of each cell is separated from that of its neighbor by the cell-walls which we have come to look upon as barriers preventing free interchange between the cells. In many cases, however, an actual continuity of the protoplasm from cell to cell has been demonstrated, and it has been recently shown that connections may be established during the cleavage period between neighboring cells. We shall not go far wrong, I think, if we assume that the protoplasm throughout the embryo is a continuous structure, and that it is not shut up in protoplasmic-tight compartments. How, then, from this point of view can we look upon the changes that take place in an unsymmetrical piece so that it becomes symmetrical? Can we regard the first step to be the same as in the piece of an egg, *i.e.*, to be the outcome of a symmetrical rearrangement of the material or substances contained in the egg? We may think of this as possible, but the change in itself would not be sufficient to account for the subsequent events, unless we assume that it leads to the symmetrical organization of the living substance itself, for on this rather than on the gross contents of the protoplasm the subsequent changes seem to depend. That this must be so is shown, I think, by the following considerations.

Numerous experiments have demonstrated that any part of the egg may produce a whole embryo — provided, of course, that it contains the nucleus and is large enough. The substances contained in the different parts of the protoplasm are very similar throughout the egg, although there may be more or less of one or of another sort in each region. Since any part of the egg can produce an embryo we cannot regard the presence or absence of any of these substances as of fundamental importance; hence it is probable, I think, that the result depends on the protoplasm rather than on the substances it contains.

The structure of the egg is a symmetrical one, as its development shows; a piece of the egg retains at first its old structure in most cases as its cleavage demonstrates, but it may later become also symmetrical, as the later changes

prove, and we are led to ask, What is the nature of this symmetry[1] or organization that exists in the protoplasm of the egg, and which may appear in the protoplasm of a part of the egg? The problem is all the more difficult to understand when we find that an egg that has divided on a radially symmetrical plan may produce a bilateral embryo. It is probable, however, in such cases that a bilateral structure is really present from the beginning of the cleavage, but that the factors that are at work during the cleavage are not necessarily those that determine the bilateral organization of the embryo. In some cases, as in the frog's egg, a careful examination even of the early cleavage stages shows that a bilateral organization is present in the protoplasm, although the form of the cleavage may appear in many cases to be radially symmetrical.

In order to answer our question in regard to the nature of the organization we should have to know more of the nature of development itself. All we can do at present is to examine some of the implications that are involved in the assumption, and at least attempt to make clear our position. The new axial relations that are established in the piece present certain interesting relations. If the original organization was a bilateral one that corresponded, let us assume, more or less with the plane of the first division, then an isolated blastomere has at first only the organization of a half, or rather contains the factors that lead to a half development. In other words, it has no median plane of symmetry, yet later such a median plane is established. It is this change, taking place in the isolated part, that we are forced to assume, that gives us one of the most interesting and also important problems with which the student of experimental embryology has to deal. We know of nothing similar taking place in inorganic nature. The most obvious change that may seem to approach this is in the formation of an entire crystal from a piece, but in this case there is never any change in the position of the original axes that the piece has inherited from the old crystal; there is no rearrangement

[1] The term "symmetry" does not, perhaps, express the idea entirely, since an egg with an asymmetrical cleavage must be regarded as having also a definite organization.

and, hence, the essential condition is absent. Our conception of the structure of a magnet must be also fundamentally different from the ideas involved in the organization of the egg. It is true that any piece of a magnet at once becomes a whole magnet of smaller size, and this occurs in the smallest pieces that it is possible to obtain. On the other hand, the change in the organization of a piece of the egg is a relatively slow one, and it can take place only in a relatively large piece of the substance. If it be objected that these differences are only trivial ones, and not essential, still it can be shown, I think, that we must hold entirely different views of the nature of the polarity of a magnet and the organization of the egg. Our conception of the polarity of the magnet rests on the idea that it is the sum total of the polarities, or, perhaps, of the orientation of the minutest elements, the molecules, of which the magnet is made up, while our conception of the organization of the egg is exactly the reverse (or at least I shall try to show that we must really believe this to be the case), and we must think of the entire egg as a whole and not the sum total of an infinite number of smaller wholes. We may claim, I think, that this property of the egg substance of forming itself into a new whole is peculiar to the living protoplasm and is a property that we do not find, or have not found as yet, in inorganic, or perhaps we may go further and say in dead, matter. If we choose to call this property of living matter a vital factor in the sense that it is not found in matter that is dead there can be, I think, little objection to so doing. If the statement seems to be arguing in a circle, we may state more simply that those properties of living things that are not shown by non-living things we shall call vital properties. We may add that we cannot be sure, at present, whether these vital factors will conflict with our present ideas of causality or not; they seem rather to be, however, new causal phenomena peculiar to certain organic substances or compounds, but it would be out of place here to examine further into these difficult questions.

I have dwelt somewhat at length on this topic because, as I shall try to show, an analysis of the phenomenon that takes place when a piece of an adult animal (hydra, for

example) changes over into a new, whole organism, leads us directly to the same conclusion.

A ring cut at any level from the body of hydra closes its open ends quickly, and in the course of a few days it elongates and assumes the typical proportions of this form. At the time of the operation the piece was a part of a definite organization, yet it afterwards becomes itself a whole structure. The material of which the piece is composed must be totipotent, since any piece may make a whole structure. The results demonstrate that although the piece must be regarded as a part of a whole organization before it was removed, yet after its removal it becomes itself a whole organism. This fact shows that there is no contradiction in our regarding the entire egg as also having a definite structure, or as being an organized whole, and yet any piece of it may become a new whole. This conclusion is of some importance because, at first, students of experimental embryology were inclined to go too far and assume that, since any piece of the egg could become a new whole, therefore, the egg itself must be regarded as a very simple structure. The experiments with hydra show that the egg *may be* as highly organized as is an adult animal, and yet a piece produce a new whole. It is scarcely necessary to add that the results do not show that the egg *is* so highly organized but only that it may be thought to be so without contradicting the results of the experiments.

I pointed out in my Woods Hole lecture of last year (1899) that from whatever part of the body a piece may be cut it will still be different in its different parts, in so far as one part was nearer the anterior end and another nearer the posterior end of the animal. And similarly for the sides of pieces of a bilateral animal, one part will always have been nearer than another to the median plane, etc. These differences suffice, I think, for us still to form a *causal* conception of how the new axial relations are attained, since the differences always present will be the basis on which the subsequent rearrangements take place, and the results of observations show, in fact, that the anterior end of the new organism comes from the anterior end of the pieces, etc. We may infer that a similar change takes place

in the reorganization of the egg; and we can form here also a causal conception of the change, although we may admit that it is a change different from anything that we know of in inorganic matter.

We may next examine some other results connected with the development of pieces of the adult and of the egg. It has been stated that a small piece of the stem of Tubularia sometimes produces only a partial form, — a proboscis, or a proboscis with reproductive organs, or a hydranth without a stem. The development of these partial structures occurs only in small pieces. The production of a proboscis, for instance, takes place only in pieces that are much smaller than the average size of the hydranth-forming region of a long piece of the stem. An entire hydranth without a stem may, however, develop from pieces that are much longer than the minimal size of the hydranth-forming region of short pieces. The point of special interest is that the development of the proboscis takes place in pieces whose material is totipotent, *i.e.*, the material can produce any part of a hydranth or of a stem. We may restate the result by saying that there is a stronger tendency, especially in the more distal parts of the stem, to form the full-sized organs than to form the whole structure in a reduced form.

These results with small pieces of Tubularia suggest at once a comparison with those cases in which a part of an egg develops into a part of an embryo, and not into a whole one of smaller size. This is most strikingly shown in the ctenophore egg and also in the egg of a snail, Ilyanassa. It has been found that, if the first two or first four blastomeres of the ctenophore egg are isolated, each not only divides as a part, but each develops into an incomplete embryo that lacks, in the case of the one-half blastomere, a half or nearly half of the entire structure, and in the isolated one-quarter blastomere lacks about three-fourths of the entire structure, etc. If pieces are cut from the fertilized but unsegmented egg of the same animal the embryos that develop from the nucleated pieces are also often incomplete. The results indicate that the phenomena are due to a lack of regulative power, or power of rearrangement

in the egg; perhaps to a lack of lability in the protoplasm, so that it fails to reorganize itself into a new whole. The result is not due to the smallness of the piece, for under certain conditions, not yet understood, a smaller piece than a half or a fourth of the egg may make a whole structure. We must, therefore, look upon the egg of the ctenophore as totipotent in all its parts, in the same way that the sea-urchin's egg is totipotent, but an incomplete embryo develops from a piece, since the egg *after* fertilization has not the power, under ordinary circumstances, of rearrangement or regulation. It is conceivable that at a different temperature or in a slightly different medium the protoplasm of the piece might rearrange itself so that an entire embryo would develop.

If we think of the embryo as organized in the protoplasm of the egg in the sense of there being present a definite structural arrangement of the protoplasm, then when the blastomere of the ctenophore egg is isolated there is simply a lack of change. If, on the other hand, we think of the egg at the beginning of cleavage as being organized only in so far as the cleavage is concerned, the later organizations appearing afterwards, then we must think of the half organization of the embryo as being induced by the half form of the cleavage, or the half form of the isolated part. The half development would, in this case, not be due to a lack of change, but to the appearance after cleavage of a half organization. If we adopt the latter alternative we can compare the development of the one-half ctenophore embryo with the production of a part of a hydranth in a small piece of Tubularia. In both cases a part of a structure is formed on account of the form or size of the piece in material that is totipotent. If, on the other hand, we adopt the first alternative we find the two processes different, unless it could be shown that towards the distal end of the piece of Tubularia a new hydranth may be organizing before the old hydranth is thrown off. The removal of a piece taking place at this time, each piece continues to develop in the determined direction. Since, however, only distal organs develop from such pieces at several levels we see that this view is insufficient by itself to give a satisfactory solution.

In regard to this latter point it seems that the development of an incomplete structure in Tubularia is not such an isolated phenomenon as it appears to be at first sight, but can be brought into harmony with certain other known results. For instance, when more than five segments are cut from the anterior end of the earthworm only five, as a rule, come back at whatever level of the anterior end the cut may be made. The amount of material that is formed at the cut-end, before differentiation begins, is about the same at all levels, and this gives, I believe, an insight into the phenomenon. There is for the earthworm, also, a lower limit of organization for the formation of the head, or of a ring of the body, and the same new part is formed at each level, because the amount of material that is at first formed over the exposed end is the same. We must look upon this material as totipotent, but the number of rings that it produces is limited, on account of the amount of material present and of the necessary connection that exists between the lower limit of organization and the volume of matter.[1] The analysis leads us in both cases to the supposition that the results are somehow dependent on the ultimate structure of the protoplasm from which arises the structure that we can see. The development of a proboscis from a small piece of the stem of Tubularia indicates that there is a quantitative element that comes into the problem, and this conclusion is directly in line with the conclusion that we reach from a study of pieces of minimal size of both adult organisms and of eggs. Below a certain point the organization of the protoplasm cannot take place, and it is this result that shows, I think, that we cannot look upon the whole as simply the sum total of similar parts, but as itself having a single plan of organization or structure.

If we next proceed to an examination of the method of development of pieces of older embryos we find some further facts that bear on our problem. It has been found that if the hollow blastula of the sea-urchin be cut in two, the opening in

[1] The form of the new part must also be a factor in the problem, for the same amount of material, if of a different shape, might give rise to more or less rings. The part of the body from which the new substance arises may be still another factor.

each piece soon closes, and a new sphere of smaller size forms from each piece. These spheres then proceed to pass through the later stages of development characteristic of the sea-urchin development. Driesch has found that if the embryo is cut in two at a later stage, when the process of gastrulation has begun, not only the piece that contains the part about to invaginate will continue to develop and produce a whole embryo, but the piece from the opposite side will also form a gastrula and embryo. If, however, the same experiment is carried out after the gastrulation has been finished, these pieces of the outer wall fail to produce a new gastrula. A similar result was obtained in still later stages in regard to the formation of the two pouches that pinch off from the inner end of the archenteron of the starfish embryo. If the inner end of the archenteron is cut off before the two pouches have formed there, they will be formed again from any part of the more proximal portion of the archenteron; but if we wait until the pouches have once been completely formed by the archenteron, and then cut off the inner end of the latter, the two pouches are not made anew at the cut-end. In other words, after the archenteron has once produced the two pouches it seems to lose *throughout* its entire length the power of repeating the process, although at an earlier stage all the parts possessed this power.

Another somewhat similar result has been recently obtained by Spemann. If a thread be tied around the middle of the embryo of the frog at the time when the medullary folds are appearing, the egg being partially constricted by the thread into a more anterior and a more posterior part, the latter will produce at its anterior end (where the string constricts the nerve plate) a new head, and there is produced in this way a double embryo with two heads, one at the anterior end, and one behind this at the middle where the constriction is present. The result shows that the material of the dorsal nerve plate is totipotent in so far as the formation of all the structures of the brain, eyes, and nerve cord are concerned, and that the position of any part in relation to the rest determines its differentiation. The brain forms at the anterior end of the nerve-plate, but it

may also appear in the middle of the plate if the middle comes to represent the anterior end, as is the case in the experiment just described.

A most important theoretical question is involved in these results, although it has not been as yet sufficiently considered by those who have carried out the experiments, *viz.*, that a stage once passed through by the embryo cannot be repeated again by the other parts of the body that may not have been directly concerned in the operation, although these parts possessed this power at an earlier stage. A thorough discussion of this important question would lead us too far from our present subject, but I may point out that the result indicates that at each stage in the development the ultimate structure seems to change its organization, so that it no longer repeats a stage once completed. The organism has not, however, lost the power of forming a new individual, or at least certain parts have not, since eggs are produced by the adult animal, each of which may make an entire organism, and the adult animal has also the power in many cases of replacing lost parts, although it does not repeat the embryonic processes in doing so.

When we examine the method of development of pieces of still later stages of the embryo we find the process more and more like that which takes place in the adult. In the higher forms (echinoderms, mollusks, annelids, and vertebrates) the regeneration of the late stages of the embryo, or larvæ, and of the adult takes place by the development of new material at the free end, while in the earlier stages in certain embryos in these groups a new whole is established by the entire structure changing over into the new form. In other words, the method of development of pieces of the early embryo is like that followed by the lower animals, *i.e.*, by a process of morphallaxis, while in the later stages of development the method of regeneration is more like that in the higher animals. The difference seems to be connected with what we call the specialization of the tissues in the later stages of development and in the adults of the higher forms, but what is meant by this specialization is a question that needs to be further examined, although it will not be possible to do so at the present time.

We have seen that there is both for pieces of the adult animal and for pieces of the egg, or of the isolated blastomeres, a lower limit of size below which a piece does not produce the typical form. Even in a form like Tubularia, in which a very small piece may produce an incomplete structure, there is still a lower limit below which the pieces do not produce any structure. We find this lack of power to develop in small pieces in which we know from other experiments that the material is totipotent, and the only clue we have to account for the facts is that the result is in some way directly connected with the *amount* of material present. We find for each animal a lower limit of size — a limit that may vary at different stages of development — for producing a miniature copy of the type form; or, in other words, the organization must have a certain amount of material in order to develop. We find this same law to hold for pieces of eggs, of embryos, and of adult Metazoa, and it is equally true for adult unicellular Protozoa. It has been found that very small pieces of the egg may continue to divide, although they may be much too small to produce an embryo; but as several other results have also indicated, the factors that determine the cleavage are not necessarily connected with those that relate to the organization of the embryo. Isolated blastomeres that are below a certain size also fail to produce an embryo. The one-eighth blastomeres and even the one-sixteenth blastomeres produce in some few cases the early stages of development, but many of them fail to do so, and beyond this point it is doubtful if a blastomere can develop past the gastrula stage. The results show that the lower limit is soon reached in these eggs. It is certain that for adult animals pieces much smaller than one-eighth or one-sixteenth of the body can produce new animals of half size, but we have at present no data for comparison between the absolute minimal size of a piece of the egg and of the adult of the same species that can produce a whole animal. It has been found that pieces of planarians that contain less than $\frac{1}{100}$ of the volume of the adult may produce the typical form. Pieces of hydra $\frac{1}{200}$ of the adult produce a new hydra; and pieces of the stem of Tubularia about $\frac{1}{245}$ of the length of the stem can also make

a new hydranth and stem.[1] The eggs produced by these forms are much smaller — hydra perhaps is to be excepted — than these minimal-sized pieces, and as the egg produces the typical form we cannot expect to find any agreement between the ultimate size of an isolated blastomere and of a piece of the adult that produces a whole structure.

Peebles found that a smaller piece of a young bud than of the wall of hydra would produce a whole organism. The result is interesting inasmuch as the region where the bud appears is also a part of the wall. We find in a growing region of this sort that the protoplasm is denser than elsewhere, and may contain at first less water than other parts of the body, so that the absolute amount of living substance may be the same in a small piece of such a bud as is contained only in a much larger piece of the wall elsewhere. If this is true, and if the egg can also be shown to contain relatively less water in its structure than do other parts of the adult animal, it may still be possible that the amount of living substance necessary to give rise to the typical form may be found to be the same in the piece of the egg and of the adult. At present, however, we lack the data necessary to make the comparison. It is certain that in many forms — as for instance in the starfish — a piece of the adult that can regenerate the entire structure must be at least several thousand, perhaps million, times greater than the egg and must contain a much vaster amount of living substance. Many other factors than that of mere size must come into play in such cases, and it seems to me that the comparison is not, after all, of much theoretical importance, since the method of development of a piece of an egg and of an adult may be entirely different.

[1] The length of the stem is so variable in Tubularia that a comparison is difficult. If we assume the length of the stem to be 35 mm., then a piece of the stem measuring $\frac{1}{7}$ mm. in length is about $\frac{1}{245}$ of the whole; and pieces of this size produced a new hydranth and stem.

II.

A year ago[1] I reviewed the different hypotheses that have been advanced to account for the phenomena of regeneration and I pointed out that if the development of a part of an egg, or of an embryo, is also a process of regeneration, as I believe to be the case, the same hypotheses ought to apply also to the development of these parts. It may be, therefore, worth while to see how far these hypotheses may account for the development of pieces of the egg or embryo.

Bonnet extended his theory of præformed germs, primarily invented to explain the development of the embryo from the egg, to include the phenomena of regeneration. At that time the development of a part of an egg was not known, but there is no obstacle at present to applying the same interpretation to the development or regeneration of parts of the egg and embryo. In fact, Weismann, who also believes in a theory of præformation both for egg-development and for development of pieces of adult organisms, has applied the same view to the development of parts of an egg. The theory of præformed germs as held during the seventeenth and eighteenth centuries need no longer be seriously discussed in the form in which it was then expressed, since we have abundant evidence to disprove the view; but the same conception has appeared again in a more insidious form in our own time, and has been applied not only to development of the egg, but also to the regeneration of both the adult and embryo. I shall not attempt to repeat here the arguments in favor of or against this view, but shall confine what I have to say to those points that bear on our present examination. The modern form of the doctrine of præformation as held by Weismann and his school is as follows. There exists in the nucleus of the egg præformed germs that correspond part for part to the later structures that develop from the egg. The process of development is a process of sorting out of the nuclear germs to different parts of the embryo, and later, by the action of the germs contained in each nucleus on the protoplasm of each cell, they

[1] Woods Hole Lectures, 1899.

determine the differentiation of the cell. In other words, the protoplasm is looked upon as a kind of indifferent medium on which the nuclear germs feed and multiply, and, replacing the protoplasm of each cell, produce there their particular product.

In order to account for the regeneration of parts of the adult it is assumed that there has taken place during development not only an unraveling of the qualities of one germ, but at the same time at each or many of the divisions of the nucleus a quantitative division of another original whole germ, or later of a part of that germ, into like parts. This second germ is a sort of reserve stuff for future contingencies, and during regeneration this reserve stuff is supposed to become active and to do what is required of it. Pieces of the egg or of the embryo are also supposed to be able to regenerate, owing to the presence of this *reserve idioplasm* or germ in each nucleus, that is awakened into activity by the injury to the whole and then proceeds by qualitative division *of exactly the right sort* to set free the necessary germs to complete the embryo.

I need not repeat here the many objections that have been brought forward in opposition to Weismann's view, or stop to point out how the upholders of this view have been obliged again and again to add subsidiary hypotheses to meet the objections that have appeared, but I may indicate at least some of the difficulties that this view meets with from the point of view of regeneration in the egg and embryo.

The hypothesis assumes that at each division of the egg a sorting out of the qualities of the embryo takes place. Observation shows, however, that at each division there is an equal division of the chromatin, and not an unequal division, as would necessarily take place in some of the divisions, if the hypothesis is correct. The experiments with the ctenophore egg indicate that the protoplasm is an important factor in the early divisions. The experiment of compressing the frog's egg during its period of division, so that a distribution of the nuclei in the protoplasm, different from that in the normal egg, is brought about, indicates that the early nuclei are equivalent; and the development into whole embryos of pieces of the egg in which

the segmentation nucleus passes through fewer divisions than in the whole egg also points in the same direction.

The regeneration of pieces of Hydra, Tubularia, and Planaria shows that at every level of the body the cells have the power of producing any part of the organism,[1] and we must regard them as totipotent, or nearly so. The same conclusion is arrived at from a study of the development of isolated blastomeres. These facts, and others that might be given, furnish, I think, a strong argument against Weismann's hypothesis, and I believe we must look in a different direction for a solution of the problem of development and of regeneration.

We should be careful to distinguish between the idea of predetermination and that of præformation. The former includes the latter, but also much more, and is, in fact, an almost necessary idea in connection with the phenomenon of development, at least in one sense. Every egg of the sea-urchin is predetermined to give rise to a sea-urchin *so long as the conditions remain as we find them at present*, but it by no means follows that the hypothesis of *præformation* is a necessary consequence of this view. It is true that since each egg passes through the same stages to reach the same goal we must regard the series of changes as predetermined in the structure or composition of the egg, and in the external conditions surrounding the egg, but the way in which the development takes place may be in no way connected with the presence of a præformed germ of the embryo or with the presence of præformed germs of any sort in the nucleus. In fact, a process of pure epigenetic development, as generally understood nowadays, may also be predetermined in the egg. It is well, I think, to be clear on this point, since otherwise we grant too readily the necessity of assuming some sort of præformation hypothesis.

In my Woods Hole lecture of last year I considered the hypothesis of formative stuffs and reached the conclusion that it is insufficient to explain many of the phenomena of regeneration. Let us see if this view will apply to the development of parts of the egg and embryo. In the first place, it should be noticed that the hypothesis was primarily invented to account

[1] At least so far as the different layers are concerned.

for those kinds of regeneration in which a new part is added at the end of the old part, and, as I have pointed out, it is not well suited to explain those cases in which a piece changes over entirely into a new whole. Since the development of parts of the egg and of isolated blastomeres and pieces of the embryo takes place by a process of morphallaxis, it is clear that the hypothesis is equally inapplicable to such cases. The kind of rearrangement or regulation that takes place in a piece of an egg, or of an isolated blastomere, or of a piece of a protozoön, so that a symmetrical whole is formed, cannot be made any clearer, I think, by the assumption of specific fluids or stuffs in the different regions that determine the later differentiation.

The idea that there is a similarity between the process by which a broken crystal completes itself and that by which an animal or a plant may make good a lost part has often been suggested. The comparison rests, I think, on a superficial resemblance, and a careful examination of the nature of the two processes shows them to be the outcome of different factors. It may, however, be asked in what respects is the modern view of crystallization different from the view which I have advocated in regard to the reorganization of the protoplasm in a part of an egg or in a piece of hydra. The two conceptions are in reality entirely different. A piece of a crystal does not rearrange its parts, much less its axes, to form a new whole of smaller size, but has deposited on its surface, from the saturated solution in which it lies, new material that conforms in every respect to the original axes and planes. In a piece of an egg or of an animal, on the contrary, the entire old structure changes over into a new whole involving in some cases a change of axes.

Pflüger's conception of the process of regeneration has many points of resemblance to the idea of the recompletion of a crystal. He applies the conception, however, only to those cases in which the regeneration is by a process of addition to the old part (epimorphosis). Pflüger's hypothesis is that at the cut-end the old material attracts from the blood new material, which is deposited over the cut-surface and is there organized at its region of contact with the old part. He speaks of the new molecules being organized at the region of contact with the

new ones, and those that have thus been organized are supposed to attract others which are then deposited on the outer end and in turn become living structures. This idea is not fundamentally different from that held at present as to the growth of a crystal, except in so far as the molecules are supposed to be organized by those in the old part or by those that have previously been altered, etc. But on this view we have no explanation of the process of morphallaxis, for, in this case, the change takes place only in the old part and throughout the old part. If we attempt to extend Pflüger's idea so that it may include these phenomena, we must suppose that a sort of recrystallization takes place in the old tissue or isolated piece; but this is really a very different conception from the former, for the process is not reorganization by apposition, but by complete working over of the entire piece into a new whole. This idea is entirely foreign to our conception of crystal growth, and also to the conception entertained by Pflüger. I have also pointed out that even in some cases in which a new part is added to the old one there are grave difficulties in the way of accepting Pflüger's view, especially in the case of the planarian, in which the new head does not appear in the middle of an anterior oblique exposed edge, but to one side of the middle line, where the influence of the old part would produce, on Pflüger's view, a very different result.

Finally, I wish to discuss a problem that is at present one of the most difficult questions in connection with the process of regeneration. I mean our idea of polarity or polarization of the living material of the animal and plant. The term was first used by Allman in 1864 to mean that a new anterior end appears on that part of a piece that lay nearest to the old anterior end, and a posterior end appears on that part that lay nearest the old posterior end. This rule is followed in a great many cases, but it is not invariable. In certain forms an organ different in kind from the one removed has been found to develop. The first case of the kind was described by Bonnet, who found when certain fresh-water worms were cut in two that the posterior piece produced at its anterior end, not a new head, but another new tail. Loeb also has described

several other instances of the same phenomenon in hydroids, and has made the additional and important discovery that in these forms the external conditions may determine the kind of regeneration that takes place. However, even in these forms differences are present in the two ends of a piece, for, even in the most favorable forms it is found that, as a rule, a new head or hydranth forms sooner on the anterior end of the piece than on the posterior, and from the posterior end of the piece a posterior end is more easily developed than from the anterior end. In other and higher forms the factors that determine the kind of regeneration seem to come from within the piece itself. In some of these forms we also find occasionally that the new part may be different from the part removed (heteromorphosis), and in some cases, as in Bonnet's fresh-water worm, a posterior end develops on an anterior surface. Other cases of the same sort are also known; for instance, in the earthworm, Allolobophora, a short posterior piece (less than half the length of the worm) generally produces at its anterior end another tail; a very short piece of the head-end may produce a new head on its posterior surface, and the same holds for short pieces of the head of a planarian.[1]

Sachs has vigorously combated this idea of polarity, that he refers to as a metaphysical notion of the morphologists, and offers as a substitute his hypotheses of formative stuffs. I have attempted to show that the idea of formative stuffs is insufficient to explain the phenomena of regeneration, and at present I see no escape from the idea of a polarity of some sort existing in the organism. On the other hand, we cannot be too careful in clearly defining what we intend to include in this idea of polarity, for I think we can see even at present that we must form a conception of the polarity different from that in which the term is used by the physicist.

The term "polarity" when used in connection with phenomena connected with the magnet means that there is a difference in the two ends of the magnet. The idea also involves the further one that any piece of the magnet also shows this same

[1] We may call that kind of heteromorphosis in which the new part is more or less a mirror figure of the old part "amphimorphosis."

difference at the ends, and since this is found to be true for every smallest piece of the magnet, it is assumed to be a property of each molecule or atom of which the magnet is made up—the magnet being the sum total of the action of all its molecules. We speak also of a crystal showing polarity in the sense that it has a definite form that can be referred to definite *poles* and *axes*, and it is supposed that this same property is possessed by the smallest "crystal molecules" of which the crystal is made.

On the other hand, in an animal or in a plant in which we find the two ends of a piece behaving differently, yet always showing the same constant difference, although we have a result resembling in many respects the polarity of the magnet, we find also in several essential respects differences and, I think, fundamental differences (in the sense that they are the outcome of different factors) between this phenomenon and that in the magnet. For instance, we find in the pieces of Tubularia that external conditions may reverse entirely, after a time, the polarity of the piece, so that a head may appear on the posterior end even while another head is present on the other end. We know of nothing similar in the case of the magnet, unless we consider the change that can be brought about in it by re-magnetization; but there are quite obvious differences in the two results. The most fundamental difference, however, between the two conceptions is, I believe, connected with the kind of structure that we must suppose to be present in the two cases. The polarization of the magnet is the sum total of a vast number of smaller units, each unit being itself a magnet. On the other hand, we have at present clear evidence to show that while the polarity of the organism is the outcome of its structure or organization, this is not the effect of the presence of a large number of units of which the organization is only the sum total, but, on the contrary, the organism is itself the ultimate unit that makes the polarity, and while we must believe that this same organization may develop in a piece of the original whole, the evidence goes to show that the reorganization is of a different nature from that by which a piece of a magnet becomes *at once* a new magnet.

In the first part of this paper I have given my reasons for looking upon the organization of living things as a phenomenon *sui generis*, and I have wished to bring here into connection with this consideration the conception of polarity as applied to the organism. It is a phenomenon, I think, that is different from the one bearing the same name applied to inorganic substances. We are therefore, I think, justified in looking upon the reorganization of pieces of the egg, embryo, and adult as a phenomenon peculiar to the living structure of the egg, and without a parallel in inorganic nature. It seems to be one of the peculiar physical properties connected with the matter that we call living substance, and in the last analysis we find it to be not simply the outcome of a complex of known physical principles. We are therefore, I believe, also justified in calling the organization of living things a vital property in the sense, to repeat what I have just said, that it is peculiar to this kind of substance or structure, and not the result of a complex of known physical principles; or, in other words, it is a physical phenomenon as fundamental as the polarity shown by crystals or the magnetism of the magnet, and just as the latter are associated with certain kinds of matter, so is the organization associated with the substance protoplasm.

THE HABITS AND NATURAL HISTORY OF STICHOSTEMMA.

C. M. CHILD.

A SMALL fresh-water nemertean, undoubtedly *Stichostemma asensoriatum* Montgomery ('96), is found very abundantly in one of the park lagoons in Chicago.

The animal has proved to be a favorable form for experimental study, and in the course of such work during the past two years a number of observations upon its habits and natural history have been made. These observations are given here in the belief that a connected account of the natural history of a single form is of value because it brings together a series of facts which, though important, often receive only incidental attention in connection with other work, or are ignored altogether, and because it affords a basis for further study.

Montgomery ('96) has given a brief description of a new American species of fresh-water nemertean which he called *Stichostemma asensoriatum*. He regards Silliman's *Tetrastemma aquarum dulcium* ('85) as insufficiently characterized, but believes that it may be closely allied to *S. asensoriatum*. The species which forms the subject of this paper agrees with Montgomery's description of *S. asensoriatum* in all respects except that it is not protandric, while Montgomery believes *S. asensoriatum* to be protandric like *S. eilhardi*. Böhmig ('98) has accepted Montgomery's genus Stichostemma for his species *S. græcense*, but as *S. græcense* is not protandric, Böhmig holds that the existence of protandry should not be regarded as a characteristic of the genus. In a personal communication very kindly made in answer to an inquiry of my own, Dr. Montgomery expresses himself as of the opinion that the presence or absence of protandric hermaphroditism is a point of minor importance. The revised genus diagnosis of Stichostemma as given by Böhmig ('98) is as follows:

"Augenzahl veränderlich, gewöhnlich mehr als 4; 9 oder 10 Rüsselnerven; das Rhyncocoelom erstreckt sich nicht bis an das Körperende; die Nephridien dehnen sich von der Gegend des Gehirns bis zur hinteren Körperspitze aus; zwitterig, ovipar." The species found in the vicinity of Chicago agrees with *S. græcense* in not being protandric, but since I cannot find that it differs in other respects from the description given by Montgomery of *S. asensoriatum*, I am inclined for the present to regard the two as identical. It appears probable, moreover, that *S. asensoriatum* Montgomery is identical with *Tetrastemma aquarum dulcium* Silliman. In any case the two forms are closely allied, as Montgomery admits.

The species under consideration is a slender worm, attaining often a length of 20 mm. (Montgomery gives the maximum length as 18 mm.). It varies in color from a light yellowish, almost cream-color, in the smaller specimens, to a deep orange-red in many of the large individuals. Even in the most brilliantly colored specimens, however, the terminal regions of the body are more yellowish than other parts. The reddish coloration is especially distinct in the nervous system. In many of the larger specimens the region of the brain can be distinguished by the naked eye on account of its deeper coloring. Individuals in which the eggs are nearly ripe show scarcely a trace of the reddish tint, being almost pure yellow in color. Animals kept in the laboratory for a long time without food usually become more or less brownish, owing to the appearance of black pigment in the integument. This pigment is occasionally found in newly captured specimens. I am inclined to believe that its appearance is connected in some manner with the lack of food.

The usual number of eyes is six, the anterior pair being the largest and the posterior pair the smallest. Variation in the number of eyes, or at least in the number of pigment spots, is of frequent occurrence. Specimens with only four eyes sometimes occur, but are rare. In case eight symmetrically placed eyes are present, the anterior pair is usually small and situated a short distance in front of the largest pair. The eyes are very often unsymmetrically placed or differ in number

on the two sides of the head. Variation in the number of pigment spots can often be observed in a single individual. One or more of the spots may divide, or in some cases a number of small masses of pigment appear in place of a single pigment spot, in consequence of a kind of fragmentation. One of these smaller masses may increase to the size of the whole, while the others disappear. Migration of these masses is often observed. A more complete account of these observations is reserved for a future time.

The body of the worm is very transparent. The alimentary canal, blood vessels, terminal nephridial organs, nervous system, gonads, the rhyncocœl, and the proboscis, with principal and accessory stilets, can be clearly seen in the living animal under slight pressure. For some time past I have employed the form for class work on account of the ease with which its internal anatomy can be studied.

The points of difference between this form and *S. eilhardi* as given by Montgomery ('96) are as follows: (1) The absence of the supraoral sense pit, which suggested the specific name "asensoriatum." (2) The cephalic gland is not as voluminous as in *S. eilhardi*, and has not one main efferent duct, but the ducts of the individual gland cells penetrate the body epithelium independently of one another, in the manner of subcuticular gland cells; the external openings of these cells lie at the anterior end of the head. The want of a main efferent duct, formed by the fusion of the individual cell ducts, might be explained by the absence of the supraoral sense pit, since in most metanemerteans the main duct discharges at the base of this pit. (3) The pigment of the body epithelium occurs exclusively in the supporting cells and is not found at all in the interstitial tissue. (4) Those gland cells corresponding to what I have termed "gland cells 3" in *S. eilhardi* are not egg-shaped, as in that species, but have an elongated narrow form; in structure and in their color reaction to stains they show a close similarity to the cells of the cephalic gland: thus, they stain intensely with hæmatoxylin, and with the triple stain of Flemming (safranin, gentian violet, orange G) combine with the safranin and not with the violet. (5) The

stilet basis is slightly constricted medially. (6) There are ten instead of nine longitudinal nerves in the proboscis.

These differences do not concern the general appearance, so that the figure of *S. eilhardi* given by Montgomery ('95, Taf. VIII, Fig. 17) might serve equally well as a general diagram of the structure of *S. asensoriatum*.

OCCURRENCE AND DISTRIBUTION.

During the early autumn of 1899 Stichostemma was found in great abundance in one of the lagoons in Jackson Park, Chicago, which has free communication with Lake Michigan. Since that time it has been present in the lagoon at all seasons of the year. Large numbers are found in masses of Spirogyra or other filamentous algæ, and often, though less commonly, the animals are found among Elodea. They are most numerous along the shore where the water is only a few inches deep. Their presence here is probably due to the higher temperature of the shallow water near the shore and the consequent more luxuriant growth of the vegetation which they frequent. Their food, which consists of species of Nais, is very abundant in the lagoon under the same conditions, and probably also, directly or indirectly, constitutes a factor in the local distribution.

The distribution about the lagoon is rather irregular and uneven. In some spots the worms are so abundant that hundreds may be taken from a single liter of the aquatic vegetation. In other spots, apparently equally well suited to these forms, only a few individuals or none at all are found. While these areas are rather definite during a single season, the worms do not always reappear in the same spot in succeeding years. It is usually necessary to hunt for the favorable localities anew each year.

The seasonal distribution is very definite. During the later summer and autumn the animals are usually very abundant, young and old together. They do not disappear from along the banks until actual freezing occurs. When the ice forms, many of the worms are undoubtedly destroyed, though a large

number of them must reach deeper water, where they continue to live beneath the ice during the winter. The lagoon is twelve to fifteen feet deep in many places, and no freezing occurs in the deeper parts. There is no evidence that the worms are capable of enduring actual freezing. After the first appearance of ice in the lagoon I have chopped out and thawed masses of the vegetation in which the worms had been abundant a few days before, but which were frozen solidly into the ice when removed. In aquaria and jars prepared from these no worms ever appeared. During the winter of 1899–1900 a part of the lagoon remained open until about the middle of January, although the weather was cold and the remainder was covered with several inches of ice. Up to this time the worms were found here in abundance. Later this area was covered with ice a foot or more in thickness, and the bottom was also frozen in the shallower parts, and at this time no worms were obtained from the region.

It is possible that the worms burrow into the mud, but samples of the mud taken at various times during the winter have never yielded a specimen. I have been unable to examine fully the deepest parts of the lagoon, but believe that the animals remain more or less active there during even the colder months.

The worms reappear near the shore in large numbers very soon after the ice begins to melt. In 1900 the lagoon was covered with from twelve to sixteen inches of ice on March 20. By March 26 the ice had melted along the shores, leaving some two or three feet of open water from six inches to a foot in depth. At this time large numbers of worms were found in this open area, nearly all of them large specimens with well-developed eggs, whereas the worms taken in January are of various sizes and mostly with very small eggs or none at all. The small worms taken in January are the young of the preceding autumn which have not attained full size. If the worms had remained inactive until the ice melted, it is difficult to understand how their increase in size and the growth of the eggs could have occurred in so short a time as three or four days. I believe, therefore, that they must have spent the month of February and the early part of March in the

deeper parts of the lagoon, reappearing at once near the surface as the temperature of the water began to rise. The small naids which form their food can be taken at all times through the winter from beneath the ice, so that so far as food is concerned Stichostemma is well supplied during the winter months.

Apparently, then, the young of the preceding autumn reach their full size during the winter, reappearing near the surface with nearly ripe eggs as soon as the ice disappears.

During the winter of 1900–1901 the lagoon was wholly covered with six to eight inches of ice before the end of December, and the temperature during the greater part of January and practically the whole of February was far below 32°. The ice became exceptionally thick and did not disappear till near the end of March. The worms were not found along the shore until April 12, and then only a few appeared, all of them large and filled with eggs which were about half grown. During the early part of December, 1900, before the lagoon was completely frozen over, the worms were more abundant than I had ever found them before. Their late appearance and small numbers in April, 1901, must probably be attributed to the protracted cold weather and the thickness of the ice in the lagoon.

During the months of May and June comparatively few full-grown specimens are found, but the young are increasingly abundant as the season advances. These become sexual about July 1 or a little earlier. By this time nearly all the old worms which survived the winter have disappeared. During the remainder of the summer the worms continue to increase in numbers until freezing kills them or drives them to deeper water.

There is no evidence that the worms possess the power of entering upon a resting stage of any kind which is capable of enduring freezing without injury, though there are some facts that indicate the possibility that they may become more or less quiescent for a short time. When the animal is brought under conditions which are disagreeable to it, or is irritated, it secretes a large amount of slime and in many cases becomes enclosed in a covering of slime, which gradually contracts and becomes more dense until it resembles a cyst. Within this the worm

may remain for some weeks, either moving slowly or not at all, or it may leave in a few days. Left in jars of clear water without algæ, the animals are likely to make these slime coverings repeatedly. As will appear below, I believe that the fact that the animal is disinclined to leave the slime is a thigmotactic reaction. Violent stimulation will often induce removal, or the slime may be picked apart with needles, thus freeing the animal, which is active and normal in appearance in every respect. In many cases mutilated specimens or animals in impure water form these coverings and remain in them until death.

It is possible that the worms may form these "cysts" about themselves during the winter. These do not, however, enable them to resist freezing and do not serve as a protection against desiccation, as will appear below. It is difficult to understand how the animal is better protected within this "cyst," except, perhaps, as regards predatory enemies, than it is under the usual conditions. While this process is perhaps to be regarded as showing the manner in which the process of encystment may arise, I think it is certain that in its present development this slime covering is of little value as a cyst. The causes and method of its formation are discussed below.

Movements.

Locomotion forward is accomplished principally by means of the cilia with which the body is covered. During the forward movement the head is turned slightly from side to side in regular succession, and as the body follows the same course the movement as a whole is distinctly sinuous, the body showing altogether four or five curves to left and right at any given time. It is probable that under normal conditions the sinuous character of the movement is a distinct aid in locomotion. In crawling through masses of algæ the lateral movements of the head will, of course, enable the animal to find the interstices more readily, while the sinuous bending of the body affords a firmer support and a greater power for forcing a way among the tangled threads. The value of these movements in enlarging

the field of direct stimulation and contact is evident. The animal crawls along the bottom of a jar with the ventral surface uppermost almost as often as in the other position. It is unable to support itself free in the water, although it often drops from the surface to the bottom, making the usual crawling movements during the descent. During all forward movement the head is continually making rapid searching movements in all directions.

Backward movement is accomplished in a manner entirely different from that just described for forward locomotion, *viz.*, by muscular contractions.

The muscular activities concerned in backward locomotion consist of a series of peristaltic waves. A contraction of the circular muscles near the posterior end occurs, and the end is thrust backward; then a wave, consisting of strong contractions of the longitudinal and relaxation of the transverse muscles, producing a shortening and thickening of the region affected, begins at the posterior end of the body and travels forward. The whole process is quickly repeated, and in continued backward movements three or four of these peristaltic waves may be visible on the body at one time. On a smooth surface like glass these movements are rather ineffective, but it is easy to see how, under natural conditions, the posterior end of the body becomes more or less completely fixed as soon as increase in size begins and the other portions are drawn back to it.

The body is extremely contractile, and different parts are capable of independent contraction. In the reassumption of the extended position after contraction, the extension usually begins at the anterior end and proceeds backward along the body as the head advances.

Movements of the proboscis within the rhyncocœl are very common. Contraction of the circular muscles in the posterior portions of the body causes the proboscis to be thrown forward, and, conversely, extension of the head region forces it backward. In general the proboscis, together with the fluid of the rhyncocœl, tends to occupy the region of least pressure.

The relation of the cilia to the different movements is interesting. During forward movement the cilia are in active

motion and constitute the chief organs of locomotion. If, however, the forward movement ceases suddenly, or if the head be slightly drawn back, the cilia in the part affected stop their movement and remain nearly perpendicular to the body surface. If the animal remains quiet for a short time the cilia may begin to move slightly. It is difficult to determine whether this movement affords any definite impulse in either direction, but observation indicates that there is a very slight backward current along the body. When the head and anterior portions of the body are suddenly and violently drawn backward, as often occurs, or if the animal begins to move backward, the cilia of the contracting region are laid flat against the body, all pointing forward, and resume their usual position when the backward motion ceases. The body is at all times covered with a thin layer of slime, and it is possible that the turning forward of the cilia may be simply the result of the backward movement of the body through the slime. Observation of the head region, which is constantly undergoing contraction and extension, shows a beautiful play of the cilia, and often in the rapid but very slight contractions without actual backward movement, the cilia over a considerable area are all instantaneously turned forward against the body, perhaps to reappear almost immediately. The rapidity and uniformity of their change of position render it probable that it is the result of a definite stimulation similar to that causing reversal of the cilia in many other forms.

I have not been able to find any indications of actual reversed beating of the cilia causing backward movement of the body. The backward movement is apparently brought about wholly by muscular contractions, the cilia being laid against the body and pointing forward, so that they offer no resistance, but remaining motionless or making very slight indefinite vibrations. These conclusions agree well with those reached as the result of macroscopic observations on the moving animal. Stichostemma does not appear to glide backward, but accomplishes this movement by violent muscular contractions as described above. Except when the stimulation is very intense and sudden, it is more likely to turn the head

back upon the body and thus to change its direction of movement, than it is to move bodily backward.

As in other nemerteans and in turbellaria, the body is always covered with a thin layer of slime or mucus secreted by the dermal glands. Any stimulation or irritation causes an increase of this secretion to such an extent that the animal becomes enveloped in a thick layer of the substance. The animal is able, like many other related forms, to move beneath the surface film, and presumably this secretion is an important factor in locomotion here and elsewhere.

Small dishes in which a number of specimens are kept become filled with long strands and masses of the slime, in which the animals move about. The accumulation of the secretion does not appear to injure the animals in any way. Wilson ('00) has noted the large amount of slime secreted by Cerebratulus, and his observations are paralleled by my own. Certainly for so small a form as Stichostemma the amount of this slime secreted is extremely large.

RESPIRATION.

Respiration undoubtedly occurs through the surface of the body. The swallowing of water which Wilson ('00) has observed in Cerebratulus has never been seen in Stichostemma. The animals are apparently sensitive to changes in the oxygen content of the water, but their small size and the absence of a cuticle probably render special respiratory organs unnecessary.

FOOD.

The only food which the animal is known to take consists of specimens of Nais which are captured and gradually drawn into the alimentary canal. The actual capture of these animals has never been observed, although in several cases they have been seen in the partially digested condition in the alimentary canal, and in one case a specimen was found with a large Nais partly swallowed. The Nais was as long as its captor, and although half its body was in the alimentary canal of the

nemertean the free portion made active movements. The nemertean was comparatively quiet, but at short intervals the mouth was widely opened and the body extended, and in this manner the Nais was drawn further into the alimentary canal. It could be clearly seen through the body wall of the nemertean that digestion of the annelid was proceeding very rapidly. Later a part of the Nais was disgorged, and some portions were seen to be completely disintegrated, while others which had been in the alimentary canal only a few minutes, ten to fifteen, showed distinct evidences of digestion. This rapid digestion of the food was also observed by Wilson ('00) in the case of Cerebratulus.

It appears extremely probable that the food is captured in the manner which Wilson ('00) has described for Cerebratulus, though I have never observed it. Indeed, there is a striking similarity between this form and Cerebratulus, both in the nature of the food and in the method of taking it. In the cases of both an actively moving annelid forms the food, being attacked and overpowered by the nemertean, and in both cases the prey is often as large as its captor and always more active. I have not been able to determine whether Stichostemma always begins the process of swallowing at the posterior end of the body of its prey. In the one case of feeding actually observed, the head of the naid had been broken off completely and lay in the slime secreted by the nemertean, but the free end of the annelid was apparently the anterior end from which the head had been broken. In the bodies of the naids which had been completely swallowed digestion had always proceeded so far that it was impossible to determine with certainty which was the anterior end.

The feeding apparently takes place only in darkness, or in light of little intensity, and therefore occurs normally during the night. During the day the nemerteans may remain in direct contact with the naids in the interstices of the masses of algæ, but apparently do not attack them. The next day, however, or after a few hours in darkness, the naids are fewer in numbers and the intestines of the nemerteans indicate very distinctly a recent meal. The failure to observe the actual capture and, in all but the one case mentioned above,

the swallowing of the food, is probably due to the fact that the nemerteans are easily disturbed by a jar or movement of the dish containing them, and especially by the light. In such cases they probably release the prey or disgorge it, if partly swallowed, as in the case described above.

There is no direct evidence that the adult animal takes other food under normal conditions. The fæces, so far as recognizable as such, always contained the setæ of naids. Moreover, specimens have been kept for weeks in jars with many other animal forms, Protozoa, Turbellaria, rotifers, copepods, ostracods, etc., but no traces of any of these forms have ever been found in the alimentary canal.

The nature of the food of the young individuals is a matter of interest. When first hatched they are less than a millimeter in length. Probably they do not take food immediately, but they certainly feed when from one to two millimeters in length. The food at this time probably does not consist of naids, for it is difficult to understand how these small animals could capture any except the very smallest. I am inclined to believe that they feed upon other small forms during these early stages, though I have no direct evidence upon this point.

I have often suspected the animals of eating each other. In jars containing a large number of specimens there is always a remarkable decrease in numbers during the first weeks, and the walls and bottom of the jar do not show the whitish disintegrating masses that are always found, even after several days, in dishes where isolated specimens die. Moreover, it is the smaller animals that disappear, those remaining being of large size and appearing well fed. I think the circumstantial evidence in favor of the view that the worms readily devour members of their own species is very strong, but here again I have not been able to make actual observations.

The animals are capable of living for a long time without food. Single specimens have been kept for more than three months in jars of clear water with no other life except probably a very few Protozoa. In one case a jar containing a number of individuals was kept for six months. Three of the animals survived during this time.

During starvation a great reduction in size occurs. During the earlier stages the animal grows somewhat more slender, but later its length is also greatly reduced. In the case mentioned in the preceding paragraph the three specimens found at the end of the six months were less than five millimeters in length, though of about the normal proportions. When placed in the jar the specimens were of average size, *i.e.*, from twelve to fifteen millimeters in length. The reduction in size was wholly due to lack of food.

The starving forms usually acquired after a few weeks a blackish pigmentation, granules of black pigment being deposited in the body wall and increasing in abundance until in some cases the body had lost its light yellowish color and become a dull, dirty brown. In such cases microscopical examination showed the whole surface of the body to be dotted with small granules of black pigment. This pigment is not altogether absent in newly captured and apparently well fed specimens, but is usually not sufficiently abundant to have any appreciable effect upon the general coloration of the body. It undoubtedly corresponds to the pigment mentioned by Montgomery ('95, pp. 99–100) as occurring as an interstitial tissue.

The increase in the amount of pigment is undoubtedly connected with some alteration in the metabolism. It is possible that it is not directly connected with starvation but with some other effect of captivity; but, as far as my own experience is concerned, it appears in specimens which have been without food for some time. Decapitated specimens or pieces of the body, which may live for months, sometimes become distinctly brown or blackish.

Reaction to Stimuli.

As regards the reactions of the animal to stimuli, it is not intended to give here the results of extended experimentation. Some work has been done along these lines, but the results are reserved for a later time.

PHOTOTAXIS.

The most conspicuous reaction is the reaction to light. The animal is negatively phototactic for even moderate light intensities. The response is very distinct and definite. If a number of animals in a dish or jar be brought suddenly into diffused daylight, each begins almost immediately to move in the direction away from the source of light. Within a few seconds every animal in the dish is moving in this manner. Arrived at the opposite side of the dish, the animals do not immediately come to rest, but move about restlessly, following the sides of the dish, or in some cases even turning back toward the light for a short distance. The final result of these movements in a cylindrical jar is the aggregation of the worms in the region of least light intensity, not at the point farthest from the light but on the two sides at a point midway between the points farthest from and nearest to the light, where a large part of the light is shut off by the walls of the jar. In this respect these animals resemble Planaria (Loeb, '93), with the difference, however, that they are more restless and do not form such distinct and well-marked aggregations under these conditions as does Planaria.

In jars kept in a dark closet or in diffuse daylight on dark, cloudy days or toward night, the worms crawl about freely; *i.e.*, they are not distinctly negative for very low intensities. Examination of a jar during the night shows the worms to be active. They are thus evidently nocturnal in habit like Planaria.

Animals from which the whole head, including eyes and brain, has been removed, react to light in the same manner as do normal animals, but the reactions are slower and less exact (Parker and Burnett, '00).

The question as to whether the reactions of Stichostemma are strictly speaking phototactic or photopathic, whether two different kinds of reaction occur, is perhaps not easily decided. Certainly, so far as experiments already made indicate, there is nothing in the reactions of the animals to light that cannot be explained as due to the effect of different intensities without relation to the direction of the rays (Holt and Lee, '01).

Thigmotaxis.

The thigmotactic reaction is positive and distinct. The animal shows a strong tendency to crawl into interstices and is usually found in masses of algæ. In clear water it will commonly select the angle between bottom and sides of the jar and gradually come to rest there.

Several specimens in a jar of clear water will often aggregate in a single mass, crawling over and between each other and finally becoming nearly quiet.

A single individual, when it changes its course of movement, does not commonly make a curve but turns the head directly back against its own body and retraces its course. Undoubtedly the animal reacts thigmotactically to its own body. In a similar manner on coming into contact with the body of another individual, or indeed any object, the worm crawls along its sides or edges, seeking the spots where the greatest portion of its body is in contact with surfaces.

Formation of "Cysts."

Since the formation of the cyst-like slime covering, mentioned above, appears to be more or less closely connected with the thigmotactic reactions of the animal, it is discussed a little more fully here.

As noted above, there is a considerable increase in the amount of slime secreted when the animal is irritated in any way. Any strong stimulation, *e.g.*, strong light, handling in a pipette, etc., appears to cause this increase in some degree. Animals placed in a jar of perfectly clear water without algæ or other places of concealment show a tendency to settle in accumulations of their own slime, and it appears, in some cases at least, that the secretion becomes more dense under these conditions. It often happens that within a day or two an animal becomes surrounded by a dense coat of somewhat elastic slime, which even after removal of the animal retains a more or less definite form. Within this slow movements may go on continuously. Sometimes the body is so closely

coiled that the covering is almost spherical, or the body may simply be bent back upon itself at one or two points, thus giving the covering an elongated form. The worm often remains in this covering for days or even for weeks, but may leave it at any time. That the animal is not incapable of making its way out is shown by the fact that violent stimulation will usually cause movements of sufficient force to rupture the wall of the covering and free the enclosed worm. The most interesting fact, and one which, as I believe, throws some light on the nature of this phenomenon, is that even after repeated stimulation or after rupture of the wall with needles, the animal in many cases exhibits an apparent reluctance to leave the covering. The head is protruded, makes the usual searching movements, and then is withdrawn again, and the worm continues its slow movements within the cavity of its case.

I believe that the enclosure of the animal within this secretion, and its apparent reluctance to leave its covering, are the result of the strong positive thigmotaxis which other actions show to be present. In a jar of clear water the slight accumulations of slime, which are the result either of irritation by strong stimuli or have been formed by the continuous secretion of slime at some particular spot where the animal has rested for a time, serve in some degree as a contact stimulus, and the worm tends to remain in or about them. Continued secretion leads to the formation of a more or less definite coat of slime, within which a cavity is formed by the continuous crawling of the worm. Various parts of the coiled and twisted body stimulate the sensitive head, giving the sensation of contact, and the head may often be seen to force its way in between two moving coils of the body, the whole body following. Thus the animal is constantly forming new figures and arranging its body in complex coils within the slime. From time to time, if the animal is well fed, the fæces and intestinal mucus are added to the wall, which thus becomes whitish and more opaque. Within the covering, then, the impulse which leads the animal to seek contact with surfaces is satisfied, and a strong stimulus is necessary in order to induce emergence. This latter fact

is clearly evident from the apparent reluctance noted above to leaving the covering, even after violent stimulation. The head being protruded finds no contact surfaces except the flat glass, and is again withdrawn. In some cases worms which had been removed from the mucous coverings happened to come into contact with the latter again in their wanderings, and after crawling about over them reëntered them, thus showing in the clearest manner possible the thigmotactic nature of their preference for these cyst-like coverings.

Another interesting habit which these worms exhibit is closely related as regards its causes and nature to that just described, and is also clearly thigmotactic. In many cases, in their restless wanderings after introduction into jars of clear water, the worms reach the surface. They may crawl anywhere upon the surface film, but prefer the margins, where the surface of the water curves slightly upward toward the glass. Undoubtedly the surface tension of the water affords a certain resistance to their movements here and calls forth a contact sensation. Into this angle between the surface film and the side of the jar the worms push their way and then crawl completely out of the water and up the side of the jar. The slime secreted by the surface prevents immediate desiccation, but becomes thicker and harder as evaporation goes on, and thus in even greater degree than the slime coverings in the water affords the sensation of contact. The worms never attempt to return to the water, but remain within the cases thus formed until death ensues, which occurs within a few hours. The whole series of reactions leading to the emergence from the water and the failure to seek it again is thigmotactic.

If the animals do not leave the water within the first twenty-four hours after being placed in the clear water they very rarely do it afterward unless they are again set in active motion by some strong stimulus. I have kept worms in a jar of this kind for three months; the only specimens which left the water did so within the first day or two, although the conditions within the jar remained equally unfavorable during the whole period.

The fact that the animals tend to leave clear water only during a short time after being placed in it is undoubtedly due

to temporary excitement in consequence of handling, strong light, etc., when first introduced into the jar. For some time they are very active and many of them reach the angle between the surface of the water and the sides of the jar. Some of them force themselves into the angle with powerful movements and thus leave the water. Later the movements become less rapid, and even when they happen to reach the angle between the water and the side of the jar they content themselves with following it or remaining quietly in it. Moreover, others have meanwhile come into contact with other individuals or with slight accumulations of slime and tend to remain quiet. It is probable that there is also some degree of acclimatization to the new conditions, so that they in themselves fail after a time to stimulate the animal as strongly as they did at first.

It is clear that the formation of these coverings cannot be regarded as constituting a true encystment. The animal does not enter a quiescent stage within the covering, nor is it enabled to survive conditions which would otherwise cause death, except that its life may be lengthened for a few moments by the formation of the covering after it leaves the water, or that it may in some cases escape the attack of predatory enemies by formation of the slime covering.

The formation of the coverings is the result of the following conditions: the surface of the body is constantly secreting slime, and stimulation or irritation causes an increase in the amount of the secretion, perhaps also some change in the quality; and secondly, accumulations of this slime are of sufficient density to call forth in some degree the positive thigmotactic reaction.

On the other hand, it is quite possible, and even probable, that the process of encystment might arise in some such manner as this in a positively thigmotactic animal. Indeed, in the present case a change in the quality of the secretion, rendering it less permeable to water, appears to be the only, or at least the principal, modification necessary for the formation of a true cyst. It is possible that in Stichostemma the secretion may become so modified in time that the animal will succeed

in tiding over the dry seasons by becoming encysted, and will then become capable of living in shallow, temporary pools, which dry up during a part of the year.

At present, however, the formation of the slime coverings cannot be regarded as an adaptation to particular conditions. It is merely an incidental result of certain reactions of the animal which have no relation to lack of water. In those cases where the animal leaves the water the result is always or nearly always death. If the nature of the secretion should for any reason undergo change in some individuals or races, selection of those secreting the most impermeable covering might occur.

The question as to whether the emergence from the water ever occurs under natural conditions requires a brief consideration. It might be supposed that in nature the animals can always satisfy the thigmotactic impulse among the vegetation and débris beneath the surface; but since the reaction is so distinct, and includes so large a proportion of the animals in clear water in the laboratory, I can scarcely believe that it does not occur sometimes in nature, and probably very often. Moreover, as is noted below, foulness of the water often induces the emergence, and in the lagoon where these worms are found the water in certain localized regions may become stagnant to a considerable degree in consequence of the decay of the luxuriant vegetation. I believe, therefore, that the animals must leave the water frequently in nature, and that these individuals are usually eliminated. It is possible that an animal which has left the water may occasionally find its way back to it, but I have never been able to observe a case of this kind in the laboratory, though I have often looked for it.

It appears probable, however, that the change from an aquatic to a terrestrial habit may be due, at least in such forms as the turbellarians and nemerteans, to a positive thigmotactic reaction which leads the animal to force itself into the angle between the surface film of the water and the substratum and thus to leave the water in the manner so well illustrated by Stichostemma. Perhaps Stichostemma itself will become able in time to resist evaporation and to obtain its food under

the altered conditions and so acquire a more or less completely terrestrial habit. At any rate this thigmotactic reaction to the surface tension of water must be regarded as one of the causes which may induce creeping aquatic forms to leave the water.

CHEMOTAXIS.

Among the chemotactic reactions the most conspicuous under conditions approaching the normal are the reactions to the composition of the water. In general the animals show some tendency to aggregate where the oxygen content is greatest. Placed in jars with masses of algæ and other animals, and kept where formation of oxygen by the plants does not occur in any marked degree, the animals aggregate at the surface as the water becomes foul. Under these conditions they are found either among the algæ just beneath the surface or crawling or resting beneath the surface film or about the margins. Furthermore, as the water becomes foul, animals which did not leave it earlier now crawl up the sides of the glass and die there. This reaction is in this case doubtless a mixed negative chemotactic and positive thigmotactic reaction; that is, the impulse to seek the surface is given by the increasing lack of oxygen or the increasing quantity of decomposition products in the water. Having reached the surface and being perhaps still restless in consequence of the chemical stimulus from the composition of the water, the worm leaves the water in response to the combined stimuli, and thus dies more quickly than it would if it remained in the water, since it possesses a high degree of resistance to the effects of foul water.

ENEMIES.

In general, Stichostemma appears not to suffer greatly from the attacks of predatory animals. Mutilated specimens are rarely found, though experiments show that even relatively small pieces of the body may live for weeks. Montgomery ('95) stated that cyprids destroy *Stichostemma eilhardi*. Under ordinary conditions I have never been able to observe that

cyprids actually attacked the active, healthy specimens. Occasionally they crawl over the body, but very soon leave it again, apparently without inflicting injury. In a series of experiments in which two or three specimens of Stichostemma were placed in small jars of clear water with hundreds of cyprids, it was found that although the worms remained alive and apparently uninjured for a day or two, they were finally completely devoured. When specimens of Stichostemma were cut in pieces and thrown into a jar containing numerous cyprids, they were rapidly devoured. In other experiments two or three worms were placed in a small dish with several dragon-fly nymphs, which were given no other food. The nymphs occasionally attacked the worms, sometimes biting them in two. Within two days the worms were usually bitten into several pieces or killed, but not devoured. At the conclusion of the experiments the same nymphs took Gammarus eagerly, thus showing certainly that they were not satiated with food. Their attacks upon Stichostemma were often observed. The worms were picked up and held by the large labium for a moment, sometimes bitten completely through and allowed to drop almost immediately, or occasionally bitten at various points and badly crushed, but not eaten so far as could be observed. The worms frequently crawled over the surface of the nymphs without exciting any response from the latter. It is of course possible that the nymphs devour small portions, but they are certainly not sufficient to satisfy the hunger of these voracious feeders.

The worms are unable to escape from predatory forms by rapid movements, for their movements are all relatively slow. It was very evident during the experiments that the nymphs often saw the worms when at some little distance from them and approached them, perhaps reaching out and grasping them for a moment only to let them drop again. In such cases the nymphs had not the slightest difficulty in approaching the worms.

It would appear that Stichostemma, especially when filled with eggs, would afford an inviting morsel for many predatory aquatic forms, and that without some means of protection its

existence in the presence of such forms in the large numbers that occur would be impossible. Its conspicuous color and slow movements render it easy of discovery and approach by those forms which use the sense of sight in finding their prey. Nevertheless the adult, the young, and the eggs appear to remain unharmed in most cases.

I am inclined to believe that the abundant secretion of slime from the surface of the body and its increase under irritation renders Stichostemma more or less undesirable as an article of food. The slime is rather tenacious, and it is possible also that small animals are unable to pierce it and thus reach the body of the worm.

The bodies of the worms when cut into pieces possess a slight but distinct fishy odor. As was determined by direct experiment, no decided taste is present. It may be, however, that the slime or the body possesses some quality which renders it disagreeable to at least some animals; but even if this is not the case, the presence of the slime must afford a certain amount of protection against attacks, at least against those of small animals.

In connection with the possibility that the slime may afford a means of protection, it is interesting to note that in the experiments with the cyprids the nemerteans became very quickly surrounded by the slime covering and remained enclosed in it until they were artificially removed the next day. In all probability the rapid formation of the slime "cysts" was the result of the incessant irritation of the surface of the worm by the cyprids crawling over it. As it formed and thickened, this slime furnished a covering which the cyprids could not penetrate, or could penetrate only with difficulty after some time.

SEXUAL RELATIONS.

According to Montgomery, *Stichostemma eilhardi* is a protandric hermaphrodite. *Stichostemma asensoriatum* is hermaphroditic, but certainly not protandric. I have never found a purely male specimen of any size. The gonads are visible in the living animals, and the small oöcytes can be seen very early

in their history. Moreover, eggs and spermatozoa leave the gonads together when the eggs are laid. By subjecting the animal to pressure the spermatozoa may often be seen in the same gonads with fully grown oöcytes, and when the egg leaves the body there are nearly always a considerable number of spermatozoa sticking to its membrane. The contact with the water apparently serves as a stimulus, and fertilization as well as maturation occurs very soon after the egg leaves the body.

From these relations it is evident that self-fertilization is possible. As a matter of fact it is undoubtedly the rule. In a large number of cases specimens which had been isolated for a week or two laid eggs, and these were always fertilized and developed. I have often removed the eggs artificially by cutting the animal into pieces, and in every case where fully grown eggs were present, fertilization occurred. The fully grown eggs can be distinguished by the fact that no peduncle of attachment is present. In younger eggs the membrane is incomplete, and the egg is in continuity with the protoplasm of the gonad through a small stalk or peduncle. I have never been able to obtain unfertilized eggs. Finally, sections of the animal with full-grown egg cells always show the spermatozoa clustered over the surface of the egg or massed in some part of the gonad, while specimens with younger egg cells show stages of spermatogenesis, and still younger stages show merely the young oöcytes and the sperm mother-nuclei. The spermatozoa, or some of them, always pass out with the egg, and I believe that each egg is fertilized by the spermatozoa of the same gonad. There is absolutely no evidence that spermatozoa reach the oöcytes in any other manner. None have ever been found in the slime which encloses the egg after it is laid in the normal manner. None have been found in the water in which many specimens had been kept. But I think the strongest evidence in favor of self-fertilization lies in the fact noted above, that spermatozoa can be seen upon the membrane of each egg cell and that the penetration of these spermatozoa can be observed immediately after the egg cell reaches the water. As in *S. eilhardi*, the genital pores are not preformed,

so that spermatozoa cannot enter from the exterior before egg-laying unless they make their way through the body wall. That this is not the case is shown very clearly by the time of their appearance, their relations to the remainder of the gonad, and by the fact that fertilization itself always occurs outside of the body. The structure and relations of the various parts of the gonads and the oögenesis afford a large number of interesting facts, but these need not be discussed in detail here. There is strong evidence that each gonad is always hermaphroditic after its original formation, and that egg cells and spermatozoa almost always develop together.

I believe that cross-fertilization occurs very rarely in Stichostemma in nature, even if it ever occurs. The egg cells when they pass out of the body are immediately enclosed in the slime from the surface, and the spermatozoa with them. While it is, of course, possible that a few spermatozoa might make their way through the slime to the water and then again through the slime surrounding the eggs of other individuals, the most careful observations have never given the slightest evidence that this actually occurs. Furthermore, if it did occur, the second set of eggs would be fertilized before such a spermatozoön could reach them.

The only possible conclusion is that self-fertilization is the rule in *S. asensoriatum*.

As a rule only one egg is formed in each gonad, but exceptions are not uncommon, though more than two egg cells in a single gonad have never been observed.

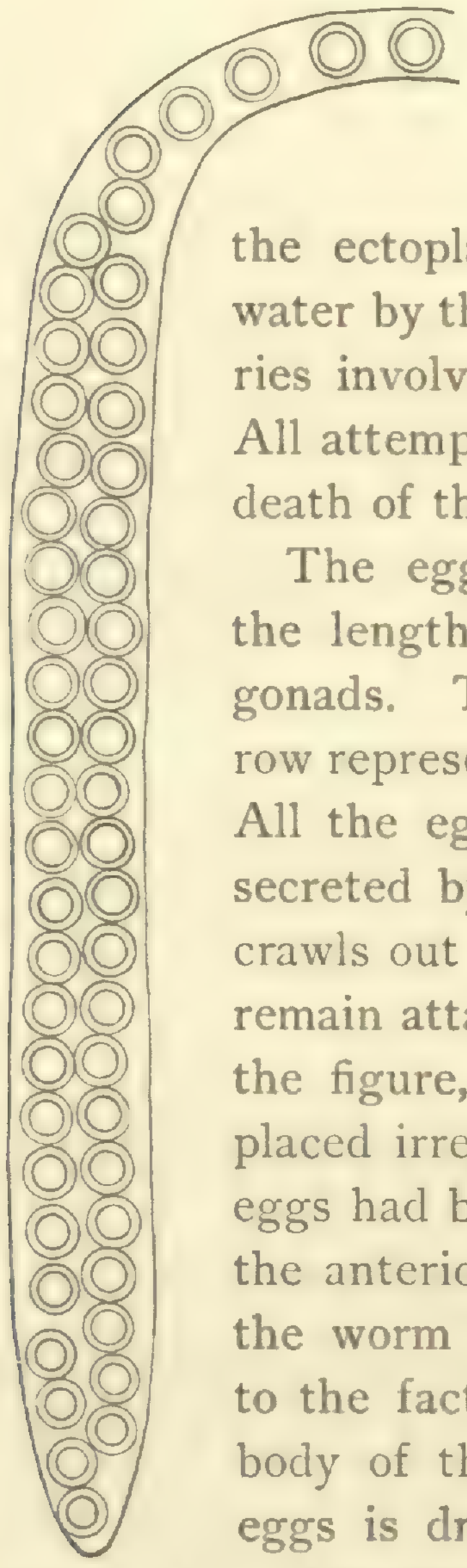
EGG-LAYING.

The normal process of egg-laying has not been observed in Stichostemma, although numerous egg strings have been found in the jars in which the animals were kept. The extrusion of eggs from the body in consequence of irritation or injury has often been observed. If an individual containing fully grown eggs be cut into several pieces, the eggs, or many of them, will often be extruded after a short time, apparently as the result of contractions following the injury. The first step in the

process is the breaking of the body wall at a definite point, *i.e.*, the appearance of the pore. Immediately after this the egg begins to flow out. The diameter of the pore is very small, so that the egg is greatly distorted during its passage. Indeed, it appears to flow out like rather thick fluid. At first a small, rounded, transparent protuberance appears at the outer opening of the pore; this is the egg membrane. Then the yolk granules and cytoplasm may be seen flowing out through the pore, and the part outside increases continually in size as more and more of the egg substance reaches it. The part of the egg outside the pore and that still within the body are connected by the slender band of egg substance which is passing through the body wall. The nucleus usually remains in the body until at least half of the volume of the egg has flowed out. The small size of the genital pore presents an obstacle to the passage of the nucleus, and often the passage of the egg ceases until some contraction of the body forces the nucleus through the narrow duct and it suddenly pops out through the pore. After the passage of the nucleus the remaining portion of the egg flows out rapidly, and the whole egg assumes almost immediately its spherical or nearly spherical form. The spermatozoa on the egg membrane can often be seen clearly during the passage of the egg, and it is evident that their movements begin as soon as they reach the water.

It is difficult to understand how definite areas of differentiated protoplasm could persist or maintain their proper position during this outflowing of the egg. To all appearances, at least, the egg flows out like a thick liquid under some pressure, and it appears scarcely possible that its parts maintain the same relative position before and after its emergence. The whole egg is enclosed, however, in a very thin layer of transparent protoplasm, an ectoplasm, and if the pressure is too great this layer is ruptured, and the cytoplasm and yolk flow out as a viscid, granular fluid, which tends to reassume the spherical form. It is evident that the cytoplasm is elastic and that the reassumption of the spherical form by the egg is due to this elasticity. Eggs in which the ectoplasmic layer has been ruptured do not develop, or at least development is confined to

the uninjured portion. All such cases of partial development die in early stages. When the yolk is exposed it appears to absorb water very rapidly, the egg or the injured part of it increases in size and becomes more transparent, and sections show vacuoles in place of the yolk granules. The death of the egg always accompanies or follows this absorption of water. Apparently the presence of the ectoplasmic layer prevents this absorption of water by the yolk. The egg is very sensitive to injuries involving the rupture of the ectoplasmic layer. All attempts to kill a part of the egg ended in the death of the whole a little later.



Egg string of Stichostemma.

The eggs are laid normally in strings of about the length of that portion of the body containing gonads. The eggs are deposited in two rows, each row representing the eggs from one side of the body. All the eggs are enclosed as they emerge in slime secreted by the dermal glands, and then the worm crawls out from between the two rows of eggs which remain attached to the substratum. As shown by the figure, the eggs at one end of the string are placed irregularly, as if the secretion enclosing the eggs had been stretched. This end is undoubtedly the anterior end of the string, *i.e.*, the end at which the worm leaves after laying, and its form is due to the fact that some of the slime adheres to the body of the worm, and together with the enclosed eggs is dragged after it as it moves away.

The cleavage of the eggs is typically spiral, all the cells being nearly equal in size during the earlier stages. The development is of the direct type. The surface of the embryo becomes ciliated, and it moves about within the egg membrane for a day or more before leaving it. The spherical embryo begins to elongate after three or four days, leaving the membrane when about one-half millimeter in length. The young animal possesses at first four eyes, the posterior pair of the adult being formed at a later stage than the others, thus

probably indicating their later origin in the species. I have not been able to ascertain whether the food of the young is the same as that of the adult.

The Breeding Season and its Relation to the Environment.

The breeding season of Stichostemma extends from May to November or December, according to the temperature of the water. Practically every specimen taken soon after the ice melts in the spring contains the growing oöcytes in the gonads, and these reach their full size, and egg-laying begins as soon as the shallow water along the shores becomes sufficiently warm. During the whole of the season from May to November the very young worms are abundant in sizes, varying from a millimeter up, and the eggs are often found in the algæ with the worms.

Egg-laying occurs freely in the laboratory. Often when the algæ containing worms are brought in and allowed to stand for twenty-four hours, a large number of egg strings will be found near the surface and on the sides of the jar. Apparently the eggs are always laid during the night or in darkness when the animals are moving about freely. Even in jars of clear water and without food the eggs are often deposited abundantly during the first few days of captivity, but individuals which do not lay eggs during that time are not likely to do so later, though, as experiment shows, they contain fully grown oocytes.

Eggs can be obtained in the laboratory at any time during the year when the worms can be found in moderate numbers. During December many individuals with oocytes at least half grown are found. In nature these eggs are probably not laid until the following spring, but if the worms are kept at room temperature in the laboratory a number will usually deposit eggs within a week or two, and this will occur even if the animals are kept without food. By these observations and those made upon animals under natural conditions during nearly two years, I am convinced that the limits of the breeding season are determined chiefly by the temperature of the

water. Probably food is actually an important factor, but its abundance is also more or less dependent on the temperature of the water, so that the latter must be regarded as the most important factor in determining the time of egg-laying.

That food is not of prime importance is clearly shown by a large number of observations in the laboratory. In animals which contained only small oöcytes when taken, and which are kept in clear water without food, the growth of the oöcytes will continue, and within a week or two eggs may be laid. This has been found to be the case even during the winter, and it shows very clearly that the important factor is the degree of temperature which permits the metabolism necessary for the formation of the yolk and the growth of the oöcyte in general. In such cases the oöcytes complete their growth either at the expense of the other tissues or some store of nutritive substance within the body. The body of the animal may even decrease somewhat in size during the growth of the oöcytes. In some way the energy of the body is applied to the completion of these important products, even at the expense of the remainder.

If an individual containing young oöcytes of small size be cut transversely near the middle of the body, and the pieces placed in clear water without food, both will usually live for months. The posterior piece does not regenerate, but the oöcytes grow much more rapidly in it than in the anterior half, and may attain their full growth and be capable of fertilization and development before those contained in the anterior half have reached more than half or two-thirds of their full size. I can explain this fact only on the basis of the difference in activity of the two halves. The anterior half, possessing a head and brain, behaves like a normal animal, moving about actively, while the posterior half, being without a brain and never regenerating a head or brain, is much less active and less sensitive to stimuli. In other words, much of the potential energy of the body which is employed in the anterior piece in producing the various movements, and probably in a more intense general metabolism, is directed in the posterior piece to the completion of the

growth of the oöcytes. These cases afford a most instructive example of the relation to each other of some of the various so-called vital activities. In the presence of the brain and anterior portion of the nerve cords the bodily movements appear to take precedence over other functions, even though the sexual products are not completed. But when the anterior portions of the nervous system are absent the animal, being without the power of regenerating the lost parts, is less affected by stimuli, and a larger portion of the potential energy is devoted to the elaboration of the sexual products. This process must, as a matter of fact, be regarded as the function next in importance to that of carrying out the normal movements and responses to stimuli.

Mention has been made of the fact that animals kept in captivity without food are not likely to deposit their eggs after the first week or two of captivity, even though artificial removal of the egg cells may show them to be capable of fertilization and development. In such cases the fate of the egg cells is quite remarkable. They may remain unchanged in appearance for two or three weeks, but after a time evidences of alteration in their structure are visible even in the living animal. The egg cells become less opaque in appearance and a clear space appears about each, apparently the result of thickening and swelling of the membrane. Later many of the eggs break up into round masses and granules, which sections show to be merely disintegration products and not cells. But the more remarkable fact is that, as the changes go on, many or all of the eggs pass out of the gonads and come to lie within the alimentary canal, where they serve as food and are actually digested. Continued observation from day to day of isolated specimens leaves no doubt that this actually occurs. In many cases the egg cells are still intact when they enter the alimentary canal and can clearly be seen there, moving to and fro with the movements and contractions of the body. Disintegration and digestion of the egg goes on rapidly in the alimentary canal, however, and in a day or two the whole intestine may be filled with a granular mass which represents the cytoplasm and yolk of the egg. In case disintegration of the egg has begun before it enters

the alimentary canal, it very rapidly becomes a granular mass recognizable as an egg only through its known origin.

That these disintegrating eggs actually serve the animal as food is evident from the fact that in a number of cases the passage of the eggs to the alimentary canal and their digestion was followed in a few days by the appearance and partial growth of new oöcytes in the gonads, each individual worm being isolated meanwhile in clear water and without other food during the whole period. In cases where the eggs were normally laid by similarly isolated specimens, new oöcytes appeared only when the first set had been laid almost immediately after the beginning of the experiment, so that the animal was comparatively fresh and probably still contained a certain surplus of nutritive material. Moreover, these oöcytes never reached a large size and usually underwent disintegration at a later period.

The manner in which the disintegrating egg cells reach the alimentary canal is somewhat obscure. Rupture of the walls of the gonad and the intestine is necessary. I believe that this rupture is brought about chiefly in consequence of the increasing disproportion between the size of the body and the size of the egg as the starving animal decreases in size, and that finally the egg becomes too large for the lateral regions of the body and is forced into the alimentary canal by the movements and contractions of the body. A study of sections reveals a decreasing thickness in the walls of the intestine and gonads, as well as other histological changes, but these need not be discussed here.

The passage of the egg cells to the intestine occurs in pieces which have been deprived of head and brain, as well as in normal individuals.

ABSENCE OF FISSION.

Benham ('97) has described a process of spontaneous fission in Carinella which probably serves as a means of distribution of the sexual products, and Wilson ('00) states that Cerebratulus fragments spontaneously at the close of the breeding

season, apparently as a means of getting rid of a portion of the body which has become of little use.

I have never observed spontaneous fission or fragmentation in Stichostemma, and have never found pieces or fragments which might be the result of such fission. Occasionally specimens are found which show slight constriction at some points, but isolation and continued observation of these individuals have always been without result. These constrictions appear not only in individuals with mature sexual products, but in other stages, and usually disappear after a few days. Moreover, they are frequently irregular, being more pronounced on one side of the body than on the other. I am inclined to believe that they are merely the results of slight injuries, for slight cuts in the sides of the body produce results which are indistinguishable from those found in freshly collected specimens.

HULL ZOÖLOGICAL LABORATORY,
UNIVERSITY OF CHICAGO, July, 1901.

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AN EXTRAORDINARY ANT-GUEST.[1]

WILLIAM MORTON WHEELER.

SINCE Sir John Lubbock's discovery of the association of certain Phoridæ (*Phora formicarum* Ver. and *Platyphora Lubbocki* Ver.) with ants,[2] several interesting additions to the number of known myrmecophiles and termitophiles belonging to this family of Diptera have been recorded. Among others a singular group of wingless Phoridæ ("Stethopathidæ") has been described by Wasmann[3] from specimens captured in the nests of termites, and Brues has recorded the occurrence of several somewhat similar forms in the nests of certain Texan ants belonging to the genera Eciton and Solenopsis.[4] Very recently Pergande[5] has published an entertaining note on the habits of a phorid (*Apocephalus pergandei* Coq.) which causes the workers of the common wood-ant (*Camponotus pennsylvanicus*) both figuratively and literally to "lose their heads," for the interior of this important portion of the ant's body furnishes the fly-larva with food and a retreat for pupation.

Far less injurious to its hosts is a myrmecophilous phorid which I propose to describe in the following pages. Unfortunately I have seen only its larval and pupal stages, but these are passed under such unusual circumstances that the discovery of the imaginal insect could scarcely supply details of very great additional interest. As the insect is not very common, many months may pass before I am able to complete my study

[1] *Contributions from the Zoölogical Laboratory of the University of Texas.* No. 23.

[2] Lubbock, Sir John. *Ants, Bees, and Wasps.* 1881.

[3] Wasmann, E. Termitoxenia, ein neues flügelloses, physogastres Dipterengenus aus Termitennestern, *Zeitschr. f. wiss. Zool.*, Bd. xlvii, No. 4 (1900), pp. 599–617, Taf. XXXIII.

[4] Brues, C. T. Two New Myrmecophilous Genera of Aberrant Phoridæ from Texas, *Am. Nat.*, vol. xxxv, No. 413 (May, 1901), pp. 337–356, 11 figs.

[5] Pergande, Theo. The Ant-decapitating Fly, *Proceedings Ent. Soc. Wash.*, vol. iv, No. 4 (1901), pp. 497–502, 2 figs.

of its life history. There is some excuse, therefore, for publishing these fragmentary observations.

On October 27 of last year I made a short excursion to Mt. Barker, which is hardly more than an hour's walk from the university at Austin, Texas. The woods about the base and on the slopes of the elevation are favorite nesting grounds for the large black ponerine ant, *Pachycondyla harpax*. In October this ant is rearing its second brood of larvæ and pupæ, having completed the education of its first brood during June and July.[1] Wishing to continue some observations on the habits of Pachycondyla, I dug up one of the largest nests I could find and carried it home in a bag. On transferring it to a Lubbock nest I took the census of the colony and found it to comprise 25 worker ants, 13 cocoons, 8 mature larvæ, 7 immature larvæ, and a packet of eggs. While counting the larvæ, which are shaped like the well-known cucurbitaceous product known as the "crook-necked squash," and covered with hairy tubercles, I noticed that six of the largest and one of the smallest presented an unusual appearance. Each of these seemed to wear about its neck a huge collar, — a sort of Elizabethan ruff, — consisting of a curled larva. That this could not be another ant-larva was apparent from a moment's examination. In all cases it almost completely encircled the ant-larva in the region of the first abdominal, or in some cases the metathoracic, segment. The posterior end was provided with a sort of disk, which adhered so tightly that both larvæ could be killed in alcohol without separating. The collar-like larva was broad behind the middle, but tapered anteriorly to a very slender thoracic region and head provided with small jaws. These were supported by a chitinous frame-work of such characteristic structure as to show that the adult form must be a true dipteron fly. The very smooth and tense integument, which was armed with some short, hooked bristles, was very transparent, so that the peristaltic movements of the viscera were clearly visible. One of the adult Pachycondyla larvæ with its living collar is shown in Fig. 1.

[1] For an account of the habits of this ant, see my paper, A Study of Some Texan Ponerinæ, *Biol. Bull.*, vol. ii, No. 1 (Oct., 1900), pp. 1–31, Figs. 1–10.

As soon as the ants had been transferred to the Lubbock nest they were given a number of young larvæ of *Camponotus sansabeanus*. These they soon proceeded to malaxate with their mandibles, twirling the morsels about in the mean time with their fore legs and lapping up the exuding juices with their tongues. Finally they deposited the crumpled and pulpy remains of the Camponoti on the trough-like ventral surfaces of their larvæ, which had been previously placed on their backs in a rough chamber dug in the earth of the nest. This chamber was immediately under the glass roof-pane, so that further developments could be closely observed with a pocket lens. Each ant-larva at once stretched forth its head eagerly and began to devour the viands with which it had just been provided. At the same moment the dipteron larva, too, as if sniffing the odor of the fresh food, unwound its tapering neck from the ventral surface of its host, and, without shifting the attachment of its posterior end, at once plunged its mandibles into the food. Under the lens both larvæ could be seen greedily dining side by side till the last particle of the Camponotus larva had been consumed or prematurely removed by the worker ants.

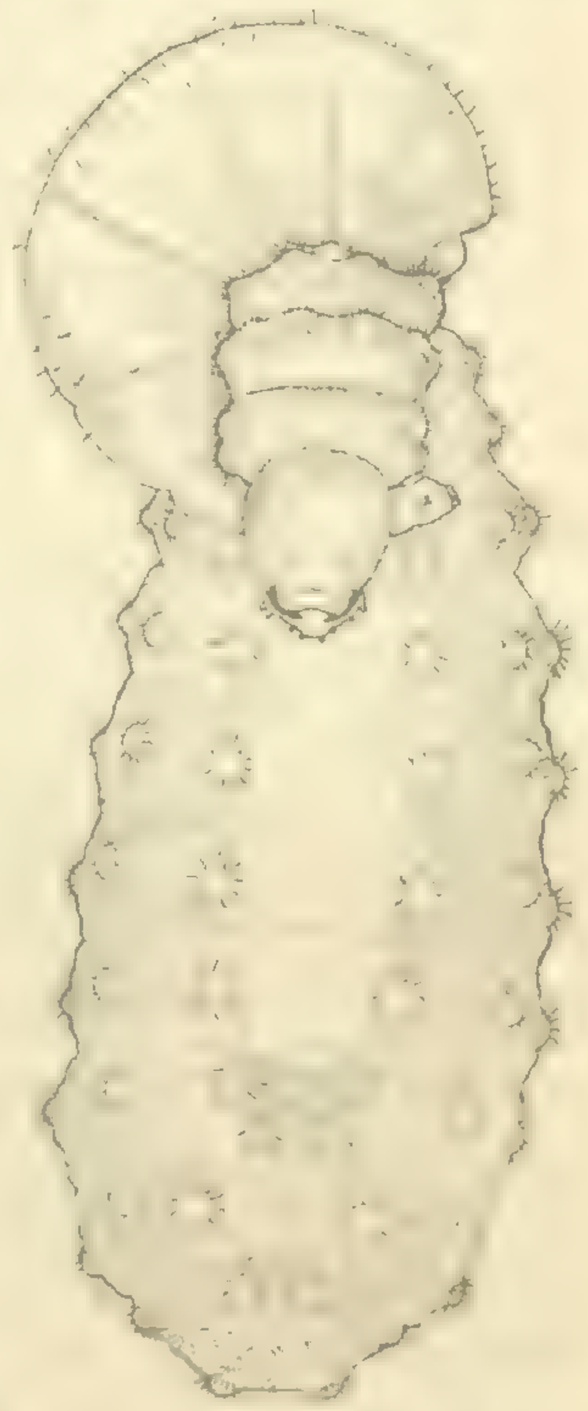

FIG. 1. — Adult larva of *Pachycondyla harpax* bearing a commensal phorid larva.

When the ant-larvæ were huddled close together, a collar-like larva was sometimes observed to reach over and help itself from the food supply of a neighbor; but even when thus compelled to crane its neck to the utmost, it never shifted the attachment of its caudal end. Sometimes when there was no food within reach it would tweak with its sharp little jaws the sensitive hide of a neighboring ant-larva, till the latter squirmed with pain. It would sometimes even tweak its own host, as if to make it wriggle and perhaps thereby incite the worker ants to bring a fresh supply of provisions.

The following day two living myriopods (Lithobius) were

placed in the nest. During the morning hours they were killed by the Pachycondyla workers, shorn of their many legs, cut up into pieces of convenient length, malaxated, and fed to the larvæ as on the preceding day. And again I was able to witness the strange banquet — the dwarf reaching down from the shoulders of the ogre and helping himself from the charger formed by the trough-like belly of his host. The same observation was repeated on several successive days. Pieces of various ant-larvæ, beetle-larvæ, Lithobius, Scutigera, Oniscus, — all were served up to the ant-larvæ and partaken of with great relish by the dipteron larvæ as well. There could be no doubt that the latter were true commensals, — perhaps the most perfect commensals, in the original meaning of the term, to be found in the whole animal kingdom!

As one of the smallest Pachycondyla larvæ, scarcely one-fourth grown, bore a very small dipteron larva, it is, perhaps, safe to say that the ant-larva acquires its commensal at a very early age. The two then grow up together, so that there is always a certain relation between the two kinds of larvæ — large Pachycondyla larvæ bearing large commensals, and *vice versa*. The worker ants lick and cleanse the commensals at the same time that they are caring for their own larvæ. This is usually done just after meals. Since, during this operation of cleansing, the ants spend no more time over the commensals than they do on a similar area of the body surface of their own larvæ, it would seem that they are not even aware of the existence of the commensals. To these nearly blind ants, which must rely almost exclusively on their senses of touch and smell, the larvæ bearing commensals, if distinguished at all from individuals without such attendants, would probably be perceived merely as having unusually protruding necks. But there is nothing to indicate that these insects are really capable of perceiving such differences in their environment.

At this time an amusing interlude in these observations was furnished by introducing into the nest a few living "pill-bugs" (Armadillidium sp.). For two whole days the Pachycondyla workers hunted these isopods from one corner of the nest to another. An Armadillidium would scurry along rather quickly

and, when overtaken, escape death by rolling itself up into a hard ball, which the ants tried in vain to perforate with their mandibles. As soon as they desisted the Armadillidium would unroll itself, and the chase would begin again. Finally I was compelled to remove the crustaceans, as the larvæ seemed to be in danger of being injured in the excitement of the chase.

On the 5th of November I obtained satisfactory evidence that the dipteron larva is not obliged to remain always with the same Pachycondyla larva. During the night one of the large larvæ had moved and attached itself to the first abdominal segment of an ant larva which already bore a commensal around its metathoracic segment. The two larvæ were oriented in opposite directions, *i.e.*, with their heads reaching around opposite sides of their host. Subsequently one of these commensals moved to an unoccupied Pachycondyla larva. I was not present when the change occurred, nor was I able to determine whether it was the originally stationary or the adventitious larva that moved. Although this observation makes it certain that the dipteron larvæ can shift their position from one host to another, I am convinced, nevertheless, that they must do this with great reluctance and only under urgent circumstances, such as extreme hunger, the death of the larva to which they are attached, or, perhaps, when fully mature and about to pupate.

As the days passed, the mature ant-larvæ spun their brown cocoons one by one, and one by one the mature commensals disappeared. Did they also pupate and for this purpose conceal themselves in the soil of the nest? or had the ants at last detected the villains and converted them into food for the larvæ which had not yet pupated? or did they stick to their hosts and pupate within the cocoons? In order to ascertain, if possible, the true state of affairs, I transferred the whole colony to a fresh nest and examined the soil of the old nest with great care. There were no traces of the missing commensals. The only remaining resource was to open the cocoons. Several of the cocoons which had been taken with the nest October 27 had hatched, but by November 10 there were still thirteen cocoons in the nest, as several of the larvæ had pupated in the mean time. Five of these were opened, and in two,

which contained pseudonymphs of Pachycondyla and were, therefore, of recent formation, commensals were found! Having shared the table of their host, they had come to share its bed as well. The dipteron, too, had pupated after the manner of its kind — forming a puparium; *i.e.*, instead of spinning a cocoon like the ant-larva, the dead larval skin, somewhat shriveled and contracted, was used as an envelope, and within this the pupa proper was formed.

This puparium, represented in Fig. 2, is from 2.25 to 2.5 mm. long and clearly of the cyclorhaph type. It is elliptical, much flattened dorso-ventrally, especially along the edges, which are thin and hyaline and almost alate. The brownish dorsal surface is thrown into delicate and irregular transverse wrinkles. Anteriorly, in the thoracic region, there is a pair of short black respiratory tubes. The ventral surface is very glabrous and distinctly paler than the dorsal surface. From its small size, cyclorhaphous character, and resemblance to the puparium of a typical Phora bred by one of my assistants, Mr. C. T. Brues, from some spider's eggs, I conclude that the insect under consideration must be one of the Phoridæ.

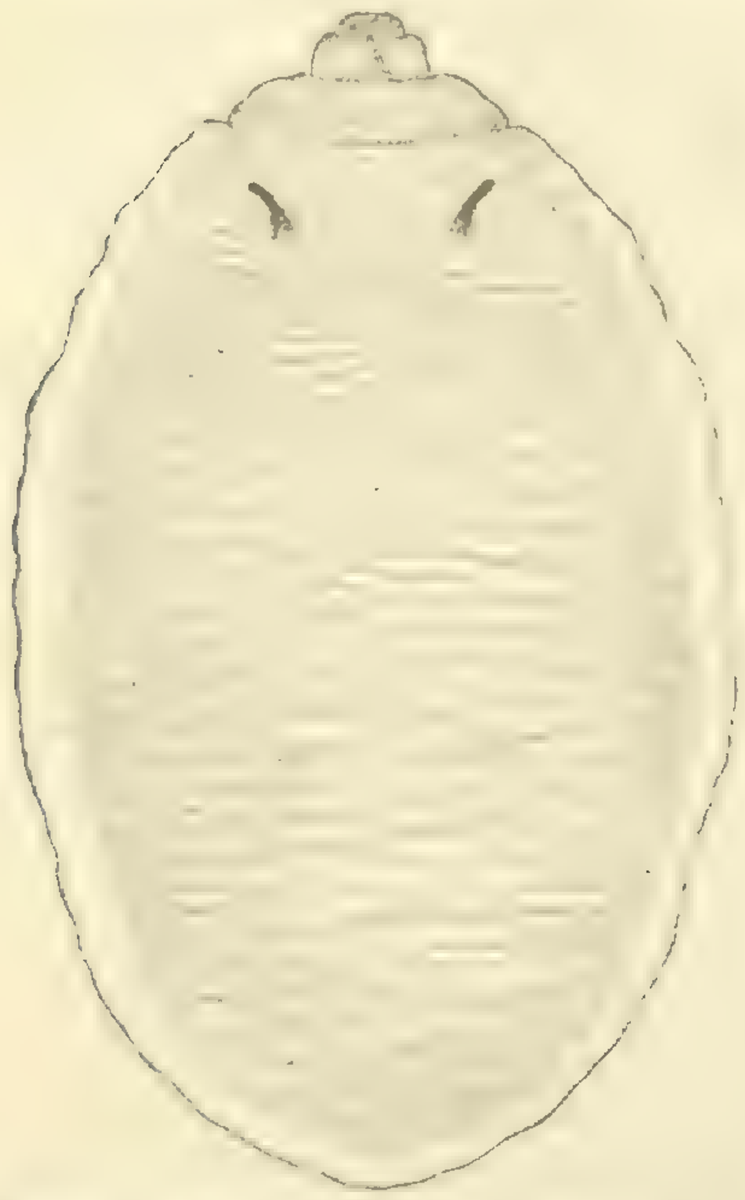

FIG. 2. — Puparium of phorid commensal from the cocoon of *Pachycondyla harpax*.

Subsequently, several other cocoons were opened and two more were found to contain the puparia of commensals. In all four cases the puparium was invariably located in the caudal pole of the cocoon, just to one side of the black blotch of ejecta deposited by the ant-larva before becoming a pseudonymph. At this point the puparium was immovably stuck to the wall of the cocoon by means of its smooth ventral surface. Its anterior end was directed towards the cephalic pole. As there is always considerable space, especially at the posterior pole, between the walls of the cocoon and the enclosed ant-pupa, the much-flattened fly puparium did not in the least crowd its host.

Reflection shows that the position of the puparium in the posterior pole of the cocoon, though the reverse of the position of the larval commensal with respect to its larval host, is the only one which can be maintained by the commensal with perfect safety. Like other ants, the Pachycondyla leaves its cocoon through a rent in the anterior pole. This rent is certainly made by the mandibles of the hatching ant, and it is possible that the callow insect may succeed in making its way out of the cocoon without any assistance from the workers. I have hitherto failed, however, to surprise one of these ants in the act of hatching. But even if the obstetrical aid of the workers is necessary, as it is in the more highly specialized Camponotinæ, any position for the commensal puparium, except at the posterior pole of the cocoon, might be fatal, for the struggling jaws and legs of the emerging ant and the jaws of the assisting ants would certainly be very liable to cut into any delicate object attached to the anterior or median walls of the cocoon. This danger, of course, would not exist if the fly hatches before the ant and is able to perforate the cocoon and escape. It is altogether more probable, however, that the ant hatches before the fly in the manner suggested below.

It would be interesting to know what the commensal larva is doing while the ant-larva is weaving its cocoon. Does it move about to avoid the swaying jaws of the spinning larva? or does it take up its position from the first at the posterior end of the larval ant and there remain motionless while the posterior pole of the cocoon is being completed? It is very difficult to answer these questions. The fact that the posterior poles of all the cocoons containing puparia were somewhat distorted, being broader, more obtuse, and more irregular than the normal cocoons, would seem to indicate that the ant-larva may modify this end of its cocoon for the better accommodation of the commensal. I am inclined to believe, however, that the distortion may be produced by the dipteron larva while attaching itself just before pupating to the newly woven and still plastic cocoon.

At this point my observations end. The phorid puparia were kept for several weeks in what I supposed to be the proper conditions of warmth and moisture, but to my intense

disappointment they failed to hatch. During the autumn and winter frequent and diligent search was made for more of the commensals in all the Pachycondyla nests I could find, but in vain. Finally, during the latter part of May of the current year, I discovered in a very different locality two Pachycondyla nests which contained a few phorid larvæ. This discovery proved that the phorid is double-brooded like its host. But the larvæ were very small and attached to such very young ant-larvæ that I despaired of being able to raise them in my artificial nests as far as the imaginal stage. It remains, therefore, for the future to fill this gap in my observations.

As a small contribution towards filling this gap I venture to advance the following conjecture concerning the circumstances under which the phorid fly probably hatches. I assume that the ant must hatch before the fly. Now very soon after the former hatches the useless cocoon is always carried by a worker and placed on the refuse heap, which in the natural nest is often almost entirely made up of the empty cocoons of from one to several broods of ants, and lies in a rather dry and well-ventilated spot immediately beneath the stone covering the nest. Along with the cocoon is carried the phorid puparium still adhering to the wall at its unopened posterior end. Thus after a privileged existence as free pensioner and bedfellow to a generous host, it is unwittingly carried away in the worn-out bedclothes and consigned to the family rag pile. Here the small and probably very active fly hatches, leaves by the wide-open front door of the cocoon, and, after mating, either returns to lay a few eggs in the galleries of its former host, or flies away to oviposit in some other Pachycondyla nest. Thus the simple assumption that the fly hatches later than the ant renders it unnecessary to suppose that the fly possesses some peculiar means of perforating the tough wall of the cocoon, and also accounts for the position of the puparium in the posterior pole, where it would be completely concealed from the workers even after the escape of the callow ant.

In conclusion the reader's attention may be directed to certain particulars of special interest in connection with the life history of the Pachycondyla commensal:

First, the peculiar habits of the phorid show clearly that the ponerine method of feeding the larvæ with comminuted insects is not only the typical but the only method employed by these ants, for such a commensal would certainly starve if the Pachycondyla larvæ were carefully fed like the larvæ of Camponotus and Formica, by regurgitation of liquid food from the mouths of the workers. The phorid profits by a peculiarity in the behavior of its host, and thereby demonstrates — by one of Nature's experiments — that *Pachycondyla harpax* cannot feed its young by regurgitation.

Second, in the peculiar symbiotic relationship existing between the phorid and the ants, the adaptations are all on the part of the former, whereas the latter pursues its ancient and well-established mode of life uninfluenced by and apparently in complete ignorance of the very existence of its little guests. Even the distortion of the cocoon may be due, as I have suggested, entirely to the activity of the phorid. These strikingly unilateral adaptations are probably to be explained on the ground that the phorid in the Pachycondyla nest is as careful and conservative — if such terms may be used — of the life and welfare of its host as Pergande's Apocephalus is ruthless and destructive. The small amount of food consumed by the former can hardly be a serious drain on the provisioning instincts of the Ponerinæ. The larvæ bearing the commensals were certainly as large and healthy as any others in the nest, and produced perfectly normal pupæ, which in the cases observed all lacked the imaginal disks for the wings and were therefore of the worker type. Whether the presence of the commensals by reducing the amount of food even to a slight degree could inhibit the development of queen larvæ and thereby convert them into workers, involves a problem as interesting as it is difficult to solve in the present state of our knowledge.

Third, the commensal of Pachycondyla, together with the Phoridæ mentioned in the introductory paragraph of this paper, shows that the flies of this family are well worth careful study. While the Stratiomyidæ, Syrphidæ, Midaidæ, etc., certainly make more attractive cabinet specimens and prettier monographic plates, it is very doubtful whether the life

histories of most of these conspicuous Diptera can compare in interest with those of the tiny, dull-colored Phoridæ. That the study of the smaller and inconspicuous Diptera, like the Culicidæ, has been unduly neglected is clearly shown by recent medical researches on the malaria parasite.

COLEBROOK, CONN., August 16, 1901.

FRIEDENTHAL'S EXPERIMENTAL PROOF OF BLOOD-RELATIONSHIP.[1]

HERBERT W. RAND.

In recent years important evidence in favor of Darwin's theory of the descent of man has increased. Eugen Dubois found in *Pithecanthropus erectus* the much-sought-for missing link between man and living anthropoid apes. Selenka has shown that, of the catarrhine apes, the living anthropoid apes resemble man in having a placenta discoidalis capsularis, while all other catarrhines have a placenta bidiscoidalis. Ernst Haeckel has accumulated evidence showing that man has descended from a line of extinct catarrhines whose immediate ancestors belonged to the group of tailless anthropoid apes, and whose more remote ancestors belonged to the Cynopithecini. The evidence afforded by comparative paleontology, comparative embryology, and comparative anatomy agrees in supporting Darwin's hypothesis.

To all this evidence is now added evidence depending upon the similarity in chemical composition of the blood of closely related animals. Comparative chemical analyses of blood are attended with great difficulties because of variations in the blood depending upon the varying conditions of nutrition in the animal. Landois, in his researches on the effects of animal blood transfusions upon human diseases, attributed his failures, so far as the beneficial effects of the blood transfusion upon the disease were concerned, to the dissolving of the red blood corpuscles of the injected blood by the blood of the recipient. Experiments upon lower animals, in the way of injecting blood from some animal of a remote species, led to the same results as the experiments upon man. The animals

[1] An extended abstract of a paper by Hans Friedenthal: Ueber einen experimentellen Nachweis von Blutverwandschaft, *Archiv für Anatomie und Physiologie*, physiologische Abtheilung, Hefte 5 und 6, 1900.

exhibited pathological conditions with development of fever, or very often died soon after the transfusion. The hemoglobin of the foreign erythrocytes appeared in the bladder immediately after the transfusion, and often more hemoglobin was given off than was contained in the injected blood. The dissolving of red blood corpuscles by the serum of foreign blood was first observed under the microscope by Creite.

Landois found, in some cases, that the dissolving of the injected blood elements did not occur. In transfusions between the horse and ass, wolf and dog, rabbit and hare, no hemoglobin appeared in the urine; the animal, even after the injection of a large amount of blood, showed no pathological symptoms, but behaved precisely as after an injection of blood from one of its own kind. Landois concluded that *only animals of very closely related species can exchange blood with impunity*. The question then arises, How closely related must animals be in order that their blood may be "physiologically identical"?

The method of blood transfusions is not adapted to extensive comparative researches. But the "globulicidal" action of a blood serum can be observed to advantage in a test-tube. To 10 c.cm. of the serum of some mammal let there be added three drops of foreign blood from which the fibrin has been removed, and let the mixture be kept at 38° for fifteen minutes. The mixture is at first opaque, because of the added erythrocytes, but at the end of the fifteen minutes the fluid regains its transparency and acquires a bright red, owing to the dissolving of the coloring matter from the added red corpuscles. Buchner found that if the serum is heated to 55° its power of dissolving foreign corpuscles is quite lost. Buchner also found that serum would dissolve the white corpuscles of foreign blood.

The loss of the dissolving power of serum as a result of raising the temperature shows that the dissolving power depends upon chemical and not upon physical factors, since, by heating, the osmotic tension of the serum is not changed.

The blood of cold-blooded animals does not respond to the test so readily as the blood of mammals, the nucleated corpuscles evidently possessing greater resistance. Non-defibrinated mammalian blood requires longer for the dissolving of its

corpuscles than if the fibrin be removed. Control experiments with superheated serum show that the dissolving, which does at length occur, is not due to the action of bacteria developed in the serum. On the contrary, the dissolving power of the serum is inhibited by the increase of bacteria.

Thus far the dissolving action of serum has been demonstrated only among vertebrates. So far as tried, the blood of invertebrates (Cancer, Arenicola, sea-urchin) has no globulicidal effect upon the erythrocytes of vertebrates (gull, rat). Among cold-blooded vertebrates the action is so slow as to be best observed under the microscope. Only the serum of Anguilla acted so rapidly as to make macroscopic observation easy. It was noted that sera which are particularly poisonous, such as the serum of Anguilla, the domestic fowl, and cat, act most rapidly upon corpuscles. This suggests that both effects are due to chemical substances of the same class.

The serum of Anguilla dissolves the corpuscles of mammals, birds, reptiles, and amphibians, and also that of other fishes. The blood of *Acanthias vulgaris* is quickly dissolved by Anguilla serum, and so is the blood of other teleosts, as *Labrus maculatus*. The effect of Anguilla serum upon the blood of other Murænidæ was not tried. The serum of Acanthias dissolves the erythrocytes of the gull, mouse, and of teleosts (Labrus, Anguilla). It is not entirely indifferent toward the blood of other elasmobranchs (*Raja batis*).

Among Amphibia, Anura are easily distinguished from Urodela by difference in blood. Frog corpuscles are dissolved by the serum of Anguilla, the gull, and cat. The dissolving power of amphibian blood is less in animals that have been kept in captivity for some time and poorly fed.

Among reptiles, the serum of some snakes was found to exceed that of amphibians in globulicidal action. Yet more powerful is the action of bird serum. This fact is parallel to the fact that the serum of birds is especially poisonous to other vertebrates. This common quality of the serum of reptiles and birds is correlated with similarities in anatomical structure which have caused reptiles and birds to be classed together as Sauropsida. The serum of the domestic fowl

dissolves the erythrocytes of animals from all other classes of vertebrates, and also of other birds.

The results of the experiments with sera of mammals agree entirely with the results of Landois's experiments with transfusions, but they do not agree with the results obtained by Ehrlich and Morgenroth, Bordet, and Gürber. This lack of agreement is doubtless due to difference in methods. The investigators named above washed out by isotonic salt solution all the serum from the erythrocytes of one animal and added large quantities of the erythrocytes to the serum of another animal. By this method in many cases no globulicidal action can be observed, while, if a small quantity of simply defibrinated blood be added to the serum, the erythrocytes are quickly dissolved. The importance of adding only small quantities of blood to the serum lies in the fact, observed by Buchner, that in the mingling of two different sera the globulicidal action may be either increased or diminished. In transfusion experiments the more blood injected the better.

The carotid arteries of a cat and an ocelot were connected so that an exchange of blood took place from one animal to the other. After a short time the blood of each animal was supposably well mingled with that of the other. No hemoglobin appeared in the bladder of either animal. The blood of the cat and of the ocelot is physiologically equivalent. If a cat and a rabbit be connected in the same way, both animals die in a few minutes from the poisonous effects of the foreign blood upon the central nervous system. Death occurs before any globulicidal action takes place. Two rabbits connected in this way exhibit no pathological symptoms.

The experiments upon mammals lead to the conclusion that among animals of the same family there are no marked differences in blood ; but the blood of animals of different suborders is not physiologically equivalent, while the blood of animals of different orders exhibits very marked mutual globulicidal action. The blood of the mouse and blood of the rat are mutually inactive. The blood of the hare and of the rabbit is equivalent; but rabbit serum dissolves corpuscles of the guinea-pig, and rabbit corpuscles are dissolved by serum of the guinea-pig,

these animals belonging to different families. The blood of the rabbit is equivalent only to that of the hare, of all the animals experimented upon.

Of Perissodactyls, serum of either the horse or ass is inactive toward corpuscles of the other, but horse serum dissolves corpuscles of the rabbit, guinea-pig, calf, lamb, and man.

Of Artiodactyls, the serum of either the ox or swine dissolves corpuscles of the other, and both dissolve corpuscles of the dog, cat, horse, rabbit, and man.

Of Carnivora, the blood of the dog, fox, and wolf is equivalent, but serum of either the dog or cat dissolves corpuscles of the other. The serum of either the cat, ocelot, or jaguar is inactive toward corpuscles of the other two animals, but cat serum dissolved the corpuscles of all the other mammals tried.

Finally, among primates, human serum dissolves the corpuscles of fishes, frog, snakes, pigeon, fowl, night-heron, horse, swine, ox, rabbit, guinea-pig, dog, cat, hedgehog, and lemur. The effect of human serum was tried upon the blood of six species of apes (the platyrhines, *Pithesciurus sciureus*, *Ateles ater;* the catarrhines, *Cynocephalus babuin*, *Macacus sinicus*, *Macacus cynomolgus*, and *Rhesus nemestrinus*, at the Berlin Zoölogical Garden). In all cases the human serum dissolved the ape corpuscles. The serum of Macacus had no effect upon the blood of some persons, while the blood of others was quickly dissolved by it.

Among the true anthropoid apes is first found blood which is physiologically equivalent to that of man. To 5 c.cm. of transparent human serum was added a drop of blood from the finger-tip of an orang-outang, and in another case from a gibbon, both young animals from the Berlin Zoölogical Garden. After twelve hours the red corpuscles were separated from the serum by the centrifuge, apparently having suffered no change, while the serum remained free from color. In three experiments, where 10 to 20 c.cm. of fresh, defibrinated human blood was injected into the veins of *Macacus cynomolgus* or *Macacus sinicus*, only a small quantity of hemoglobin appeared in the urine, — scarcely more than is found in the serum as a

result of the defibrinating process. The animals suffered no ill effects from the operation. Twenty-five cubic centimeters of human blood was injected into a ten-year-old chimpanzee. For two days the urine was tested and showed no signs of hemoglobin or albumen. The injected blood apparently produced no effects whatever. It has been shown by successful blood transfusion experiments that the blood of such widely separated races as the negro and white is physiologically equivalent.

These blood comparisons, as well as the embryological researches of Selenka, justify placing man and the anthropoid apes together in the same family, or at least in the same suborder, rather than isolating man in a suborder of primates, coördinate with the suborders of the platyrhines and catarrhines.

The chemical similarity of the blood of morphologically similar animals is not surprising. The thing inherited through the ovum and spermatozoön is not "innere Impulse," "Iden," or "Entwickelungsmöglichkeiten," but a certain definite chemical composition of the molecule. Development, form, and the nature of the metabolic processes are as closely dependent upon the chemical composition of the molecule as any chemical reaction is dependent upon the chemical composition of the reagent causing it. Similarity in the chemical composition of blood is but one factor in the chemical similarity of closely related organisms. The chemical similarity of reproductive cells must be regarded as an epitome of all the chemical similarities of the adults.

It is well known that the horse and ass, dog and wolf, rabbit and hare readily cross. It would be a valuable experiment to attempt, by means of artificial fertilization, a cross between the rat and mouse, or between the domestic cat and the ocelot. The physiological similarity of the blood of either pair of animals points toward the possibility of a successful crossing.

QUARTERLY RECORD OF GIFTS, APPOINTMENTS, RESIGNATIONS, AND DEATHS.

EDUCATIONAL GIFTS.

Alameda, California, $35,000, from Andrew Carnegie, for a public library.

Amherst College, $2000, by the will of Professor Herbert B. Adams.

Armour Institute, $250,000, from Mrs. Philip D. Armour and J. Armour.

Arnold Arboretum of Harvard University, $126,485, from various sources, for its endowment fund.

Barnard College, $1500, for fitting up the zoölogical laboratory.

Berea (Kentucky) College, $50,000, by the will of Stephen Ballard of Brooklyn.

Bethany (Kansas) College, a conditional gift of $25,000, from Dr. D. K. Pearson.

Burlington, Vermont, $50,000, conditional from Andrew Carnegie, for a public library.

Carson-Newman College, $45,000, from John D. Rockefeller; $15,000, from other sources.

Chatham, N.Y., $15,000, from Andrew Carnegie, for a public library.

Colorado College, $100,000, from an anonymous donor.

Columbia University, $100,000, from an anonymous donor, for a department of Chinese; $10,000, for the purchase of books; $5000, for a historical reading room; $5000, for general purposes, from an anonymous donor.

Cornell University, a conditional gift of $250,000, from John D. Rockefeller; an astronomical observatory and equipment, from General A. C. Barnes.

Dartmouth College, $100,000, from Amos Tuck, for a building for the school of administration and finance.

Des Moines (Iowa) College, a conditional gift of $25,000, from John D. Rockefeller.

Detroit, Michigan, $750,000, from Andrew Carnegie, for a public library.

Drury College (Missouri), $25,000, from Dr. D. K. Pearson; $25,000, from other donors, for a science building.

Eureka (Illinois) College, $60,000 in land, from Mrs. D. Bandy.

Fairmount (Kansas) College, a conditional gift of $25,000, from Dr. D. K. Pearson.

Fargo College, a conditional gift of $50,000, from Dr. D. K. Pearson.

Georgia State Normal School, a conditional gift of $13,000, from G. F. Peabody.

Hamline University, $50,000, from James J. Hill; $30,000, from M. G. Norton.

Harvard University, $1,000,000, from J. Pierpont Morgan, for buildings for the medical school.

Illinois College, a conditional gift of $50,000, from Dr. D. K. Pearson.

Kenyon (Ohio) College, $50,000, from Senator Mark Hanna.

Leadville, Colorado, $100,000, from Andrew Carnegie, for a public library.

Massachusetts Institute of Technology, $100,000, from the alumni, for a gymnasium; $10,000, from George A. Gardner.

McKendree (Illinois) College, a conditional gift of $50,000, from Dr. D. K. Pearson.

Middlebury (Vermont) College, $12,500, from Ezra J. Warner; $5000 from Dr. M. Allen Starr.

Milliken University (formed by the union of Lincoln College and the Decatur Industrial College), $150,000, from James Milliken.

New York Botanical Gardens, $3200, from Misses O. E. P. and C. P. Stokes.

Princeton University, $50,000, for a library fund; $10,000, for a fellowship: $150,000, from the alumni, for a gymnasium; $10,000 for a fellowship in biology, from Mrs. Maule.

Radcliffe College, about $200,000, by the will of Susan Cabot Richardson; $25,000, by the will of John Sweetser.

Riverside, California, $20,000, from Andrew Carnegie, for a public library.

Rockefeller Institute for Medical Research, $200,000, from John D. Rockefeller.

San Francisco, California, $750,000, from Andrew Carnegie, for library purposes.

Smith College, $28,000, by the will of Mrs. Louise Frisbie; a conditional gift of $100,000.

Stevens Institute of Technology, $50,000, from President Henry Morton.

Syracuse University, about $40,000, by the will of Justice George N. Kennedy.

Tulane University, $50,000, for library purposes, from Mrs. Caroline Stannard Tilton.

University of Chicago, $3000, by the will of Marie J. Mergier; $75,000 additional, from A. C. Bartlett.

University of Southern California, $100,000, from various donors; a conditional gift of $40,000, from Mrs. Anna Hough.

University of Virginia, an annual income of $11,000, from Mrs. Mary Austin Carroll, of Boston.

Vassar College, $28,000, by the will of Mrs. Louise Frisbie.

Washington and Jefferson (Pennsylvania) College, $100,000, from J. V. Thompson.

Wellesley College, $28,000, by the will of Mrs. Louise Frisbie.

Whitman College, a conditional gift of $50,000, from Dr. D. K. Pearson.

Yale University, $10,000, from Irwin Rew, for the Sheffield Scientific School: $25,000, from John S. Newbury, of Detroit, for an organ.

APPOINTMENTS.

Dr. Lujo Adamovič, professor of botany in the University at Belgrade. — Dr. Ludwig von Ammon of Munich, honorary professor. — M. Eugen Autran of Geneva, botanist to botanical gardens at Buenos Ayres. — S. M. Bain, professor of botany in the University of Tennessee. — Dr. Charles R. Bardeen, associate professor of anatomy in Johns Hopkins University. — Arthur W. Bean, assistant in histology and embryology in Cornell University. — Professor H. C. Beeler, state geologist of Wyoming. — Dr. Louis Beushausen, professor of geology in the mining school at Berlin. — Professor Franz Beyschlag, second director of the Prussian Geological Survey. — Dr. G. Bodländer, professor of geology in the technical school at Braunschweig. — Dr. J. Böhm, custodian of the collections of the mining school and geological survey in Berlin. — H. W. Britcher, assistant in zoölogy in the University of Maine. — W. E. Britton, state entomologist of Connecticut. — E. R. Buckley, state geologist of Missouri. — Dr. A. H. R. Buller, lecturer in botany at Birmingham University. — Charles W. Bunker, assistant in histology and embryology in Cornell University. — Louis R. Cary, assistant in biology in the University of Maine. — Professor Fridiano Cavara, professor of botany in the University at Catania. — Dr. Frederic E. Clements, adjunct professor of botany in the University of Nebraska. — Professor H. W. Conn, lecturer on agricultural biology at the Connecticut Agricultural College. — Rheinhart Parker Cowles, fellow in zoölogy in Johns Hopkins University. — Dr. Max Cremer, professor extraordinary of physiology in the University at Munich. — Dr. R. A. Daly of Harvard, assistant on the Geological Survey of Canada. — Dr. Percy M. Dawson, associate in physiology in Johns Hopkins University. — Earl Douglass, fellow in biology in Princeton University. — Mr. R. Evans of Oxford, curator of the Museum at Demarara. — Mr. M. N. Fenneman, professor of geology in the University of Colorado. — Bruce Fink, professor of geology and botany in Drake University, Iowa. — Dr. J. S. Flett, assistant in petrology on the geological survey of the United Kingdom. — Dr. Joseph Marshall Flint, professor of anatomy in the University of California. — Dr. Shepard I. France, instructor in physiology in Dartmouth College. — Adolf Fritze, professor of zoölogy in the University of Tokyo. — Dr. Karl Wilhelm Genthe, instructor in natural history in Trinity College. — Dr. Paul Goode, instructor in geography in the University of Pennsylvania. — H. H. Grau, docent for botany in the Bergen (Norway) Museum. — Dr. Emily Ray Gregory, professor of biology in Wells College, Aurora, N.Y. — Professor Eugene Haanel, of Syracuse, superintendent of mines in Canada. — Dr. E. Haunig, docent for botany in the University at Strassburg. — Dr. Charles M. Hazen, professor of biology in Richmond College, Virginia. — Dr. Tracy F. Hazen, director of the Fairbanks Museum of Natural History at St. Johnsbury, Vt. — Dr. Wilhelm Hein, docent for ethnography in the University at Vienna. — Dr. Herbert, docent

for zoölogy in the University at Heidelberg. — Bert R. Hoobler, assistant in histology and embryology in Cornell University. — F. W. Hodge, assistant in charge of office in the Smithsonian Institution. — Dr. Charles F. Hottes, instructor in botany in the University of Illinois. — J. Allen Howe, geologist on the English staff of the Geological Survey of the United Kingdom. — Dr. Alois Jenčić, assistant in vegetable physiology in the University at Vienna. — Dr. Duncan S. Johnson, associate professor of botany in Johns Hopkins University. — S. P. Jones, assistant state geologist of Georgia. — Dr. Ernst Kittl, docent for geology in the technical school at Vienna. — Dr. Alfred Koch, professor extraordinary of bacteriology in the University at Göttingen. — Dr. F. Kolbeck, professor of mineralogy in the mining school at Freiburg i. S. — Dr. A. L. Kroeber, instructor in Indian anthropology in the University of California. — Dr. August Langhofer, professor extraordinary of botany in the University at Agram, Austria. — Dr. Ralph S. Lillie, assistant in physiology in Harvard Medical School. — Dr. Walther von Lingelsheim, director of the bacteriological station in Benthen, Germany. — George H. Lyman, professor of botany in Dartmouth College. — Dr. Florence M. Lyon, associate in botany in the University of Chicago. — Dr. Albert F. Matthews, assistant professor of physiological chemistry in the University of Chicago. — Dr. Hermann Meerworth of Hamburg, assistant in the Natural History Museum in Braunschweig. — Adam Miller, fellow in biology in Princeton University. — Benjamin LeRoy Miller, fellow in geology in Johns Hopkins University. — Dr. Siegfried Mollier, professor extraordinary of anatomy in the University at Munich. — Dr. G. T. Moore of Dartmouth College, algologist to the Department of Agriculture. — H. B. Muff, geologist on the Scottish staff of the Geological Survey of the United Kingdom. — Dr. Müller, director of the newly established zoölogical garden in Halle. — Dr. Bogumil Nemec, head of the new institute of vegetable physiology in the Bohemian University at Prag. — S. P. Orth, professor of natural science at Buchtel College, Ohio. — William Osburn, instructor in zoölogy in the University of Cincinnati. — Dr. J. B. Overton, professor of biology in Illinois College. — Vládimir J. Palladin, professor of vegetable anatomy and physiology in the University at St. Petersburg. — Dr. Henry F. Reid, professor of geological physics in Johns Hopkins University. — Ralph W. Richards, fellow in biology in Tufts College. — Professor I. C. Russell, state geologist of New Jersey, to take the position next year. — Dr. Wilhelm Salomon, professor extraordinary of stratigraphy and paleontology in the University at Heidelberg. — Dr. E. Schellwein, professor extraordinary of geology and paleontology in the University at Königsberg. — Dr. Edward C. Schneider, professor of biology in Tabor College, Tabor, Iowa. — Dr. G. Senn, docent for botany in the University at Basel. — W. T. Shaw, assistant entomologist in the Iowa Agricultural Experiment Station. — Daniel Naylor Shoemaker, fellow in zoölogy in Johns Hopkins University. — Dr. F. L. Stevens, instructor in biology in the North Carolina College

of Agriculture. — H. H. Thomas, geologist on the English staff of the Geological Survey of the United Kingdom. — John J. Thornber, professor of botany in the University of Arizona. — William C. Thro, assistant in histology and embryology in Cornell University. — William George Tight, president of, and professor of geology in, the University of New Mexico at Albuquerque. — Dr. O. Uhlworm, editor of the *Botanisches Centralblatt*, librarian of the Royal Library in Berlin and chief of the German Bureau for International Bibliography. — C. E. Van Orstrand, physical geologist of the United States Geological Survey. — Dr. W. Voigt, custodian of the Natural History Museum in Bonn. — Dr. Franz Wähner of Vienna, professor of mineralogy and geology in the German technical school at Prag. — Professor Dr. Eugen Warming, director of the Danish Geological Survey. — Dr. Sho Watase, professor of zoölogy in the University of Tokyo. — Dr. Thomas L. Watson, professor of geology and botany in Denison University, Granville, Ohio. — Dr. Karl Wenle, professor of anthropology in the University at Leipzig. — Gersham F. White, assistant in histology and embryology in Cornell University. — Dr. Edwin M. Wilcox, professor of biology in the Alabama Polytechnic Institute, Auburn, Ala. — Dr. A. W. G. Wilson, assistant on the Geological Survey of Canada. — William F. Wismar, assistant in histology and embryology in Cornell University. — W. B. Wright, geologist on the Irish staff of the United Kingdom. — Dr. Rudolf Zuber, professor of geology in the University at Lemberg.

RESIGNATIONS.

Dr. E. B. Copeland, professor of botany in the University of West Virginia, legislated out of position by the regents. — Dr. C. L. Herrick, from the presidency of the University of New Mexico, on account of ill health. — F. W. Hodge, ethnologist in the Bureau of American Ethnology at Washington. — Professor Carl Wilhelm von Kupffer, from the directorship of the Anatomical Department of the University at Munich. — Dr. E. Suess, from the professorship of geology at Vienna, after nearly fifty years' service. — Dr. H. Topsöe, director of the Danish Geological Survey. — Dr. Arthur Willey, from the curatorship of the Museum at Demarara.

DEATHS.

Dr. G. A. Asp, professor of anatomy in the University at Helsingfors, April 25, aged 66. — Rev. Dr. Willis H. Barris, geologist, at Davenport, Iowa, in May, aged 79. — Alexander Becker, a Russian botanist and entomologist, April 16, aged 82. — Professor M. G. Bleicher of Nancy, known for his researches on the geology of the Vosges. — Dr. E. Bretschneider, author of several works on Chinese botany, in St. Petersburg. — Dr. Gino Ciaccio, professor of comparative anatomy in the University of Bologna. — Dr. E. W. Claypole, sometime professor of geology in Buchtel

College, Akron, Ohio, and lately professor of geology in Throop Institute, at Long Beach, Cal., August 17, aged 66. — A. Constant, student of Lepidoptera in Golfe Juan, France, May 13, aged 71. — Maxime Cornu, professor of botany in the Jardin des Plantes, at Paris, April 4, aged 58. — Adolf Fick, professor of physiology in the University at Würzburg, August 21, aged 71. — H. W. Harkness, botanist, in San Francisco, May 10, aged 80. — W. Hartwig, curcinologist, in April, in Berlin. — Rev. Moses Harvey, who added much to our knowledge of the giant squid, at St. John's, Newfoundland, September 3, aged 82. — Professor Felix Joseph Henri Lacaze-Duthiers, the eminent French zoölogist, aged 80. — Professor Gustav Lindström, paleontologist of the Royal Museum at Stockholm, May 16, aged 72. — Dr. Otto Lugger, entomologist of Minnesota since 1887, May 21. — Dr. P. Calvin Mensch, professor of biology and chemistry in Ursinus College at Collegeville, Pa., July 30. — Dr. Joshua Miller, archæologist of Arizona. — Dr. Charles Mohr, botanist, at Asheville, N.C., July 17. — P. G. von Möllendorff, a writer on the natural history of China, April 19, aged 53. — Dr. Adolf Erik Nordenskjöld, the well-known arctic explorer and naturalist, August 13, aged 68. — Miss Eleanor A. Ormerod, the British entomologist. — Dr. Antonio Piccone, algologist, in Genoa, May 21, aged 57. — Dr. Otto vom Rath, well known for his studies of myriapods and cytology, in Cologne, April 23, aged 43. — Miss Eva M. Reed, botanist and indexer in the Missouri Botanical Gardens, killed by a train July 7. — Dr. A. F. W. Schimper, professor of botany in the University at Basel, September 9, aged 45. — Dr. Domenico Stefanini, professor of bacteriology in the University at Pavia, aged 80. — Professor C. A. Tenne, custodian of the Berlin Mineralogical Museum at Bad Nanheim, aged 48. — Friedrich Tiemann, conservator of the Zoölogical Museum in Breslau. — Anthony Wilkin, an English archæologist and ethnologist, at Cairo, Egypt, May 17, aged 24. — Martin F. Woodward, demonstrator in biology in the Royal School of Science at South Kensington, drowned September 15.

CORRESPONDENCE.

Editor of the American Naturalist:

SIR:—A slight correction should be made in my "Notes on Living Nautilus," which appeared in the October number of the *American Naturalist*. I notice that on p. 828 the block of cuts 6, 7, and 8 has been set so that the animals seem to be looking somewhat upward. To appear accurately, the three figures should be rotated downward, clock-hand fashion, each about thirty degrees.

BASHFORD DEAN.

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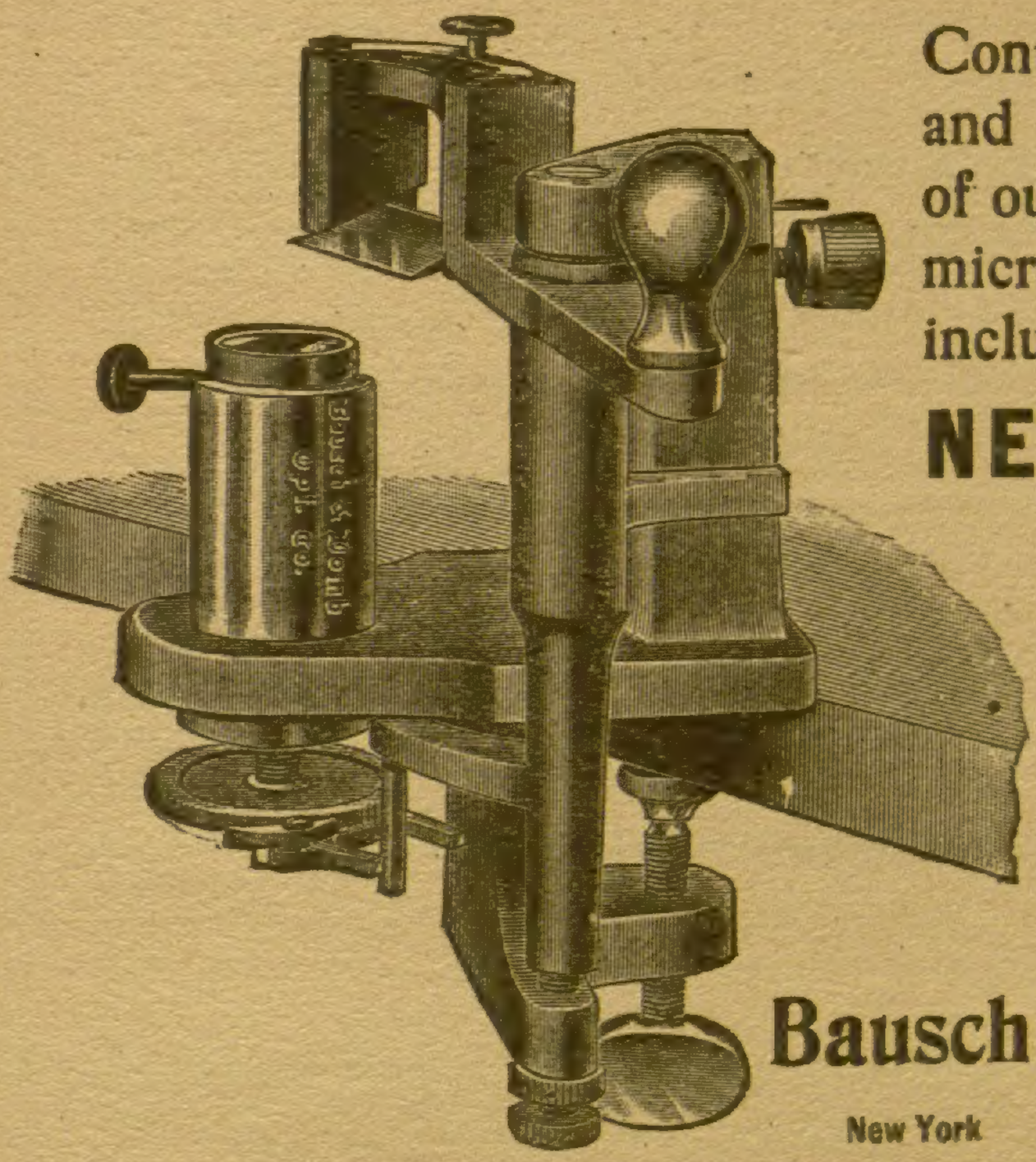

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